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CONVERSION OF THE ATLANTIC CITY LINE OF THE WEST JERSEY & SEASHORE R. R. CO. (PENNSYLVANIA R. R. SYSTEM) TO ELECTRIC TRACTION.

The well-known high-speed route, Camden to Atlantic City, a route whose regular train service is among the fastest in the world, has for two months past had an electric train service in addition to the old service. The new electric line is an old steam railway, belonging to the West Jersey & Seashore Ry. Co., of the Pennsylvania R. R. system, and forming one of the Pennsylvania's two lines between Camden and Atlantic City. The map reproduced in Fig. 1 herewith shows the electric line by a heavy full line, while the steam-operated divisions of the Pennsylvania R. R. in southern New Jersey are shown by broken lines. As may be seen here, the main Camden-Atlantic City line of the Pennsylvania is quite direct, closely parallel to the Atlantic City R. R. of the Philadelphia & Reading system, while the line which has been equipped for electric operation makes a detour to the south. The distance by the Pennsylvania's direct route is 59 miles, by the other 65 miles. The latter, however, has connection with all important points in the southern end of the state. Its most important branch leaves the line at Newfield and goes via Millville to the important summer resorts of the Cape May coast. Of this branch the part from Newfield to Millville has been included in the electric equipment. In fact, the Cape May branch has hitherto been the main line of the division in question, and the present electric line to Atlantic City is a new development as regards through traffic between Camden and Atlantic City. A branch line, single-track, from Newfield to the outskirts of Atlantic City was in existence, and this, with the Camden-Newfield part of the Cape May line, was reconstructed to form a double-track through line to Atlantic City for the projected electric service. This is the line described in the present article.

An important feature of the creation of this new through route is the disposition of the not inconsiderable freight traffic which the Cape May and Newfield branches carried. The principal part of this traffic went to Cape May, Sea Isle City and neighboring points, where a large summer population congregates. This part of the freight it has been possible to remove entirely from the electric route. Trackage rights were obtained over the Atlantic City R. R. (P. & R. Ry.) line from Winslow Junction to the crossing between Woodbine and Sea Isle Junction. All Cape May freight of the West Jersey & Seashore R. R. will hereafter be carried over the main line from Camden to Winslow Junction, thence south over the Atlantic City R. R. to the junction near Woodbine, and thence to destination over the company's own tracks. In fact, this routing has been followed since the beginning of the installation of the electric equipment. Local freight, for points not reached by this route, is hauled over the electric route by steam locomotives during the hours of minimum density of train movement (night).

This enterprise is of peculiar interest because it is the longest piece of electrically-equipped steam railway main line in the country, and will probably retain this distinction until the New York, New Haven & Hartford inaugurates its electric service between New York and New Haven, Conn. No less noteworthy a feature of the Atlantic City line is the remarkably short time in which the work was done. Active construction was begun about the beginning of 1906, and regular train service was initiated on Sept. 18, 1906. Thus little over eight months was required for the extensive construction work involved in the change. The building of the power-house is perhaps the most striking instance of the remarkable dispatch which characterized the undertaking. The site for the power-house was chosen on Jan. 17, 1906; the first pile for its foundation was put down two days later, and on July 1, 1906, the first train to take current from the power-house was run. On Sept. 18 the line was placed in regular operation. The extent of the work required for this improvement is made apparent by the following summary:

ELECTRIC PASSENGER CAR.

TRACK:	
Length of track relaid with new rails..	48.1 miles.
Length of new second track.....	36.6 miles.
Length of new third track.....	6.5 miles.
New rail laid.....14,126 tons.	
Splices replaced by special splices for track bonding .....23,577 pairs.	
New third rail (100 pounds).....10,198 tons.	
New long ties, for third rail insulators..83,857	
Siding laid .....13,400 ft.	
New track switch connections.....	15
SIGNALS:	
Length of track provided with automatic block signals.....	35.5 miles.
Length of track provided with telegraph block signals	25 miles.
New automatic signals installed.....	86
New telegraph block signals installed..	24
New signals at interlocking.....	201
New signal bridges.....	45
FENCING AND CATTLE GUARDS:	
Fencing	87.5 miles.
Cattle guards installed.....	370
TELEPHONE AND TELEGRAPH:	
30 pair telephone cable.....	8.5 miles.
Telegraph cables	6 miles.
Telephone wires	260 miles.
Telegraph line rebuilt.....	12 miles.
Telegraph wire changed.....	190 miles.
BRIDGES AND CULVERTS:	
12 pile bridges; total length.....	1,150 ft.
One 30-ft. four-track concrete arch....	2,800 cu. yds.
Center and rest piers for double-track drawbridge in "Thoroughfare," Atlantic City.	
Trestle in "Thoroughfare" for drawbridge	500 ft.
Land trestle approach for drawbridge..	600 ft.
STATION CHANGES:	
Platforms moved back.....	16
Stations and freight houses moved back.	10

In addition to these figures, the following items must be noted: At Camden, the west end of the line, a new terminal has been built, adjoining the present ferry terminal. The work at this point includes a number of stub-end tracks with suitable sheltered platforms between them, and ¾-mile of new elevated double-track trestle, with stone piers and steel superstructure at street intersections, which connects this terminal with the existing lines, at grade, at a point near Haddon Ave. At the east end of the line, from a point about two miles from Atlantic City a new right-of-way has been secured, and after crossing the Thoroughfare on a new drawbridge the tracks cross the Philadelphia & Reading Ry. on an elevated structure, which includes nine concrete piers with steel superstructure, and enter the Atlantic City terminal on a descending grade. This terminal is new, and, like that at Camden, consists of a number of stub-end tracks with concrete platforms between them, with steel umbrella shelters. It is located on the south of the present steam terminal. New terminal facilities have also been provided at Millville, the southern end of the electric division of the Cape May branch, including 100 ft. of umbrella shelter sheds.

The line from Camden to Atlantic City is double-track throughout, with a third track between Camden and Woodbury. From the Camden terminal to Newfield the road is laid with 100-lb. rail of the Pennsylvania R. R. standard cross-section, and from Newfield to Atlantic City it is laid with 85-lb. rail of the Am. Soc. C. E. section. The line from Newfield to Millville is single-track and is laid with 100-lb. rail of standard Pennsylvania R. R. cross-section.

The electric-traction system is of the familiar direct-current type, at 650 volts on the contact conductor. A third-rail is used on the entire distance from Camden to Atlantic City, excepting a stretch of 4.4 miles between Haddon Ave. and South Gloucester, where the track passes

through the streets of Camden at grade; on this portion an overhead trolley wire is used. The 10-mile branch from Newfield to Millville is equipped with overhead trolley throughout.

The power-supply and distribution system has been planned with a view to accommodating a very heavy traffic. The equipment of generating station and substations, as well as the transmission line and contact conductor, are designed to be capable of handling a schedule comprising: three-car express trains, 15 mins. apart in each direction, between Camden and Atlantic City, running at a speed of 60 mi. per hr. on straight level track; two-car local trains between Camden and Millville (on the Cape May branch), 30 mins. apart; and single cars between Camden and Woodbury 10 mins. apart. The initial schedule includes three-car express trains between Camden and Atlantic City on one-hour intervals, the running time being 90 mins., and a local service of two, three and four-car trains run on a minimum interval of 15 mins. during the rush hours between Camden and Glassboro, ever fourth train going on to Millville.

The rolling stock consists of motor cars exclusively, no trailers being used. The car construction and equipment are described further on.

A general outline of the electrical system is as follows: Three-phase alternating current at 6,600 volts is generated in a power-house located near the Delaware River, where coal and water supply facilities are good; it is transformed to 33,000 volts in the power-house, and is transmitted over a duplex aerial transmission line to seven substations (an eighth substation is located in the power-house), where the pressure is lowered to 430 volts and the current converted to direct-current at 650 volts pressure, which latter is fed to the contact conductor. The power-house is located just north of Westville, N. J., on Big Timber Creek, 5.6 miles from the Camden terminal, where there is an abundance of water for boiler-feed and condensing purposes. The substations are located as follows: South Camden, Westville (in power-house), Glassboro, Newfield, Clayville, Mizpah, Reega and Atlantic City.

POWER-HOUSE.

It has already been stated that the site for the power-house was chosen on Jan. 17, 1906, and that the first pile was driven on Jan. 19, and as this building in all probability was erected at a greater speed than any other power station hitherto built in the United States, some additional data may be of interest to show the rapidity with which the work progressed.

The power-house, boiler house and stacks are built on approximately 850 concrete piles. The foundations, which were started on March 15, are of reinforced concrete and are superimposed upon the piles in such a manner that the latter project about one foot into the mass of concrete, making a thoroughly homogeneous foundation. The boiler foundations were completed by March 25, and those for the steam turbines by June 5. The erection of the steel work for the main building was begun on April 18. On March 5 the foundations for the stacks were started and these were completed by the 25th of the same month. The steel work for the stacks was started on April 11, and the first stack was erected, lined and ready for use by June 29.

A host of other dates and figures might be given, but the most significant of all, as showing the rapid progress of the work, is that on July 1, just 5½ mos. from the date upon which the first pile was driven, two boilers were under steam at working pressure, a turbine and all the necessary auxiliaries were running, the substation in the power-house was in operation, and the first car to take current from the power-house was run on the line. Fig. 2 shows the completed structure, and Fig. 4 gives an interior view.

The central part of the power-house equipment comprises three 2,000-KW. generators, driven by direct-connected Curtis steam turbines; the units are of the vertical type. They produce three-phase alternating current at a frequency of 25 cycles and a pressure of 6,600 volts. Steam is supplied by 12 Stirling water-tube boilers, arranged in six batteries of two each. Each boiler is rated at 558 HP., a total of 4,300 HP. A superheater in connection with each boiler furnishes steam at 125° F. superheat. The steam pressure is 175 lbs. per sq. in. A longitudinal coal-bunker over the central aisle of the boiler-room feeds the coal by vertical chutes into small cars run on a series of three tracks in the aisle. These cars also serve for ash removal. The coal-bunker is fed by a conveyor from a crusher tower outside, to which the coal is elevated by a bucket hoist from a receiving hopper under the railway track. The general arrangement of the power-house equipment is represented in the skeleton cross-section drawing Fig. 3.

Three barometric condensers, built by Williamson Brothers, in connection with Cramp & Co., of Philadelphia, who were also the sub-contractors for the circulating and air pumps. These condensers are capable of maintaining a vacuum of 28 ins. and are designed to condense 60,000 lbs. of steam per hour with circulating water at a temperature of 70° F. The approximate ratio of condensing water to steam condensed is 37.1. The condensers are served by three dry air pumps built by I. P. Morris & Co. and three centrifugal circulating pumps built by the I. P. Morris Co., and driven by Reeves engines. The piping for these engines is so arranged that the

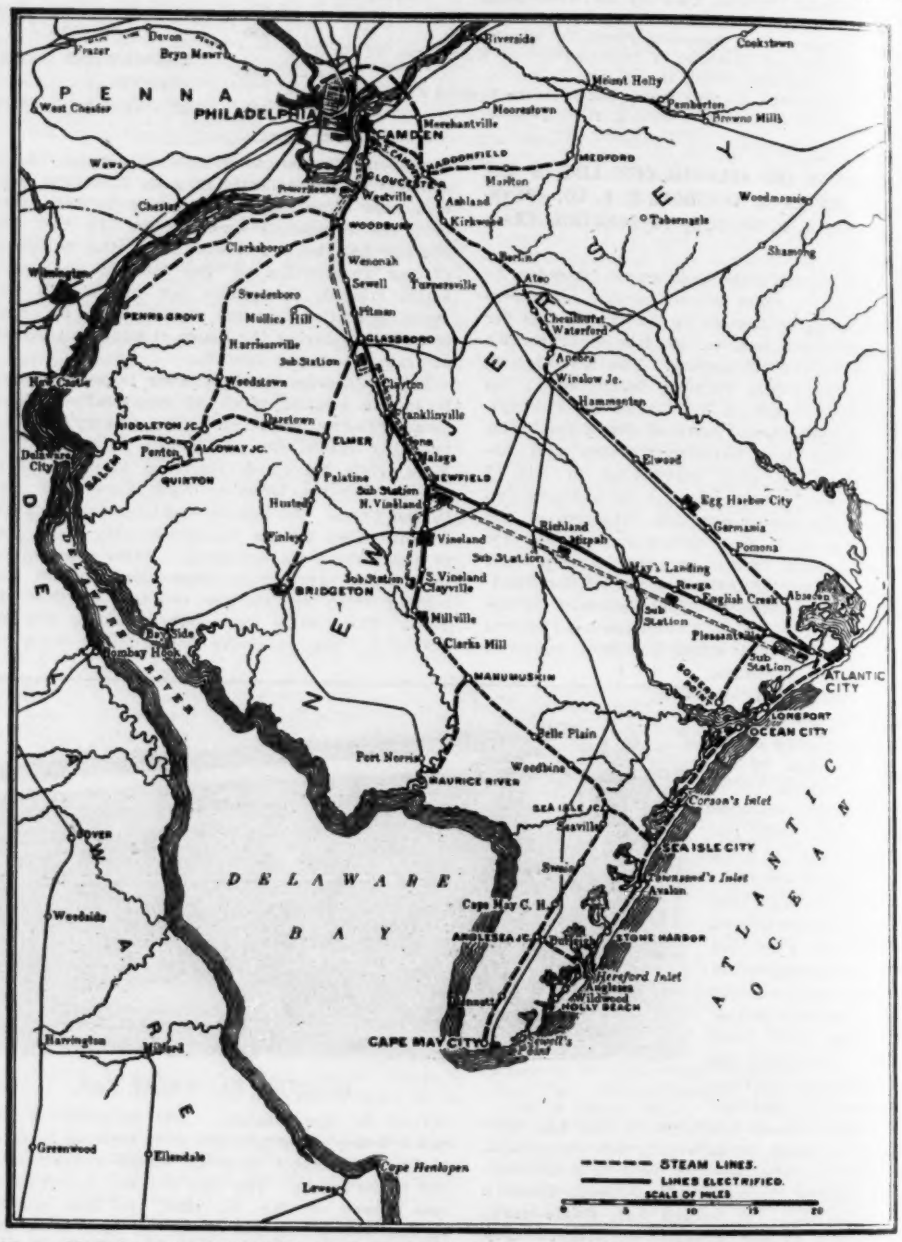


FIG. 1. MAP OF THE SOUTHERN PART OF NEW JERSEY, SHOWING THE NEWFIELD LINE BETWEEN CAMDEN AND ATLANTIC CITY, PENNSYLVANIA R. R.
Equipped for Electric Operation (Direct Current) by the General Electric Co.

The engine-room, while now equipped with but 6,000 KW. of generating machinery, has space for a fourth 2,000-KW. unit and its auxiliaries; the foundation for the additional unit is already built. Further, one on the end walls of the station is of temporary construction, to facilitate lengthening the station in the future when more than 8,000-KW. capacity is called for.

The principal auxiliaries in the station are:

Two exciter sets, each consisting of a horizontal Curtis steam turbine coupled to a 75-KW. four-pole General Electric D. C. generator running at 2,400 r. p. m. and delivering 600 amperes at 125 volts pressure. The turbines of these sets work non-condensing, as the exhaust is used for heating the feed water.

exhaust may be discharged to either the feed-water heater or to the third stage of the turbines, the latter arrangement only being used when the exhaust from the other auxiliaries exceeds that required for the feed-water heater.

Two Cochrane feed-water heaters, each capable of heating 135,000 lbs. of water per hour from 70° F. to 212° F.

Two boiler-feed pumps, two make-up pumps, two step-bearing pumps, and two step-bearing return pumps, all of Worthington make.

One step-bearing accumulator, capacity 100 gals. water at 800 lbs. per sq. in., made by R. D. Wood & Co.

The generated current is handled by nine 700-KW. 25-cycle step-up transformers (6,600 to

33,000 volts) cooled by air blast. The latter is supplied by three blowers, each capable of furnishing 20,000 cu. ft. of air per min.

The area of the power-house is 17,069 sq. ft., and the cubic contents amounts to 829,113 cu. ft., thus giving 2.13 sq. ft. and 103.6 cu. ft. per KW.

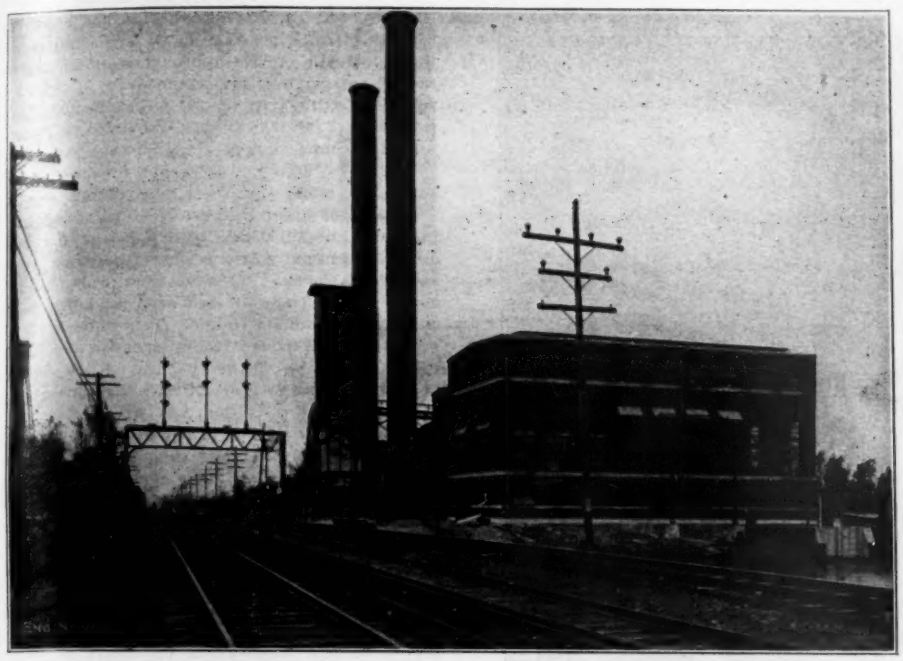


FIG. 2. GENERAL VIEW OF POWER-HOUSE, WESTVILLE, N. J.

as the unit output of the station, based on 8,000 KW. as the ultimate capacity of the present structure.

The layout of the steam piping in the power-house is of a very neat design and allows ample operating space around all the machinery. W. K. Mitchell & Co., of Philadelphia, Pa., were the sub-contractors for this work, together with the steam valves, etc., and Keasby & Mattison furnished the pipe covering. The exhaust mains from the turbines to the condensers are of unusual form, being rectangular riveted steel conduits, as may be seen in the view Fig. 4.

SUBSTATIONS.

The equipments in the several different substations vary according to the requirements of the several portions of the road they supply. The following table shows the number and capacity of rotary converters installed in each substation together with the extra capacity provided for:

Name of substation.	Rotary converters already installed.	Additional rotary converters provided for
South Camden	2 750-KW.	1 750-KW.
Westville (in power-house)	2 750-KW.	1 750-KW.
Glassboro	2 750-KW.	1 750-KW.
Newfield	2 750-KW.	1 750-KW.
Clayville	2 500-KW.	1 750-KW.
Mizpah	2 500-KW.	1 750-KW.
Reega	2 750-KW.	1 750-KW.
Atlantic City	2 750-KW.	2 1,000-KW.

The rotary converters, of standard General Electric design, are capable of running at 150% full load for two hours with a temperature rise not exceeding 55° F. The transformers are all supplied with taps giving one-third and two-thirds of the working voltage to enable the converters to be started from the A. C. side. This method of starting needs no synchronizing and should the D. C. polarity of the machine chance to come in the wrong direction it is readily changed by means of the field reversing switch provided for this purpose. By this method, any of the rotary converters can be started, run up to full speed, and be delivering power to the line within a minute. Three air-cooled transformers are provided for operation in conjunction with each rotary.

The disconnecting switches and lightning arresters in each substation are located in a separate room. The high tension circuits are of bare copper wires supported on insulators on a pipe framework, and each pole of the oil switches is enclosed in a separate brick compartment.

For the purpose of illustration, the intermediate substations with two 750-KW. rotary converters are selected as being typical. Fig. 5 gives a plan and transverse section of one of these. In the arrangement of the equipment every precaution has been taken to provide for the continuous operation of the road under all traffic and weather conditions.

The substation buildings are of red brick, trimmed with Indiana limestone facings, and the floors are of concrete. Each substation is furnished with a hand-operated crane capable of handling any of the machinery installed. It is a matter of interest that the substation buildings, including the foundations, were built in sixty working days, and that the installation of machinery was accomplished in thirty working days.

The poles are of chestnut, their height being 45 ft., with extra long poles where special conditions require. They are spaced 125 ft. apart, but at street crossings the spacing is reduced to 100 ft. Head guys are used at distances of approximately one-quarter mile. There are two cross-arms, the top arm being 12 ft. in length, carrying four insulators, and the lower arm 8 ft. 6 ins. in length, carrying two insulators. The six wires form two inverted equilateral triangles 42 ins. on a side (Fig. 6). The three wires in each triangle are transposed by one complete spiral between each substation. The cross-arms are bolted to the poles and as an additional support they are stiffened with galvanized iron braces.

Locke insulators made in three parts and mounted on iron pins are used. They are designed to stand double the working pressure. Each petticoat was tested separately, the top section to 45,000 volts. In each case these tests lasted four minutes, and following this the assembled insulator was subjected to 85,000 volts for ten minutes; also, a precipitation test was made at 52,500 volts.

A unique feature of the transmission line is the method of protection from lightning: A seven-strand galvanized steel cable $^5/_{16}$-in. in diameter is strung for the entire length of the line on top of the transmission poles, 4 ft. above the nearest active wire, and provided with ground connections at every fifth pole. This is believed to be an efficient supplementary adjunct to the arresters as a protection against lightning.

In all there are 71 mls. of transmission line. This was erected at a speed of from one-half to two miles a day, including digging the holes and erecting the poles, besides stringing six wires and tying them to the insulators.

CONTACT CONDUCTORS AND TRACK WORK.

As already noted, except for two sections, respectively 4.4 mi. and 10 mi. long, the line-conductor is a third-rail; on these two sections an overhead trolley wire used. The third-rail is placed 26 ins. out from the track rail, gage to gage, with its contact surface (top) 3½ ins. above top of rail. These dimensions are the same as used on the Interborough Rapid Transit Ry. (New York), and in the Long Island R. R. electric

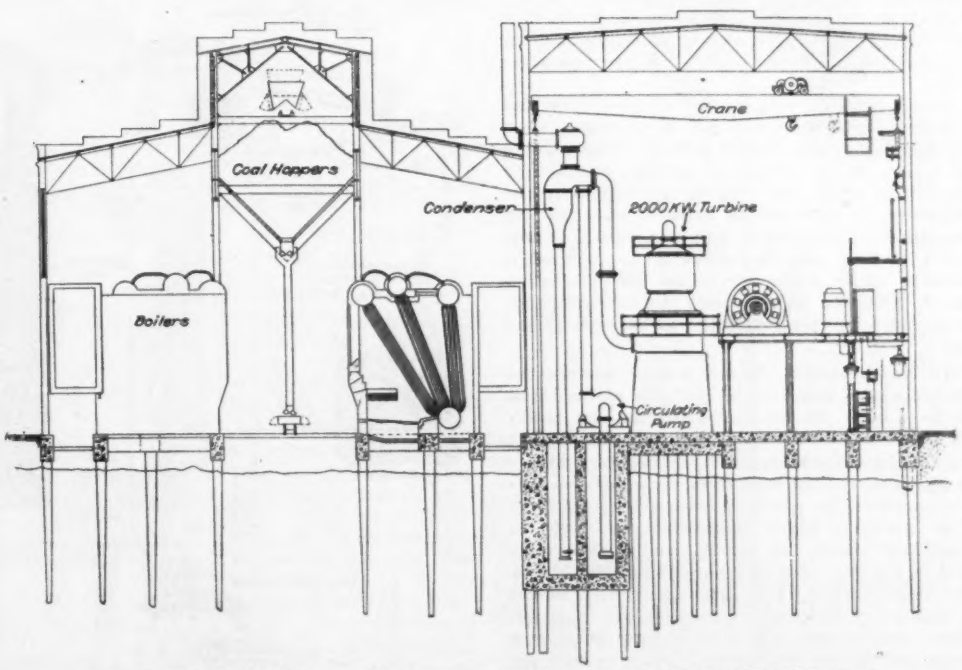


FIG. 3. DIAGRAMMATIC CROSS-SECTION OF POWER-HOUSE, WESTVILLE, N. J.

The sub-contractors for the substation buildings were Lynch Brothers, of Philadelphia, Pa.

THE HIGH-TENSION TRANSMISSION LINE.

The 33,000-volt transmission line is in duplicate throughout. It is Y-connected, with the neutral grounded, and consists of six No. 1 B & S hard-drawn solid copper wires mounted on porcelain insulators, terminal equipment, and are standard with the Pennsylvania R. R. The trolley wire, where used, is over the center line of the track, 22 ft. above top of rail.

The third-rail is of the composition and section standard for rails on the Pennsylvania R. R., weighs 100 lbs. per yd., and is laid in lengths of 33 ft. Its conductivity is approximately that

of a copper rod of 1,200,000 circular mils. cross-section. The form and composition were determined by the desire to have the third-rail interchangeable with the track rails. The third-rail insulators are spaced about 8 ft. on centers. They are of "Reconstructed Granite," and in form are simple rectangular blocks, 5 ins. × 10 ins. and 3½ ins. deep, with a raised lip along either 5-in. edge to hold the rail against lateral displacement. A cylindrical pocket in the bottom face of the block fits over a metal cup fastened to the tie by a screw. This fastening permits the depression of the tie under train load without putting the insulator under tension. There is normally no fastening between third-rail and insulator, but at intervals the third-rail is anchored by metal clamps, attached to the foot of the rail, of such shape as to engage the ends of the insulator, to fix the rail in position longitudinally.

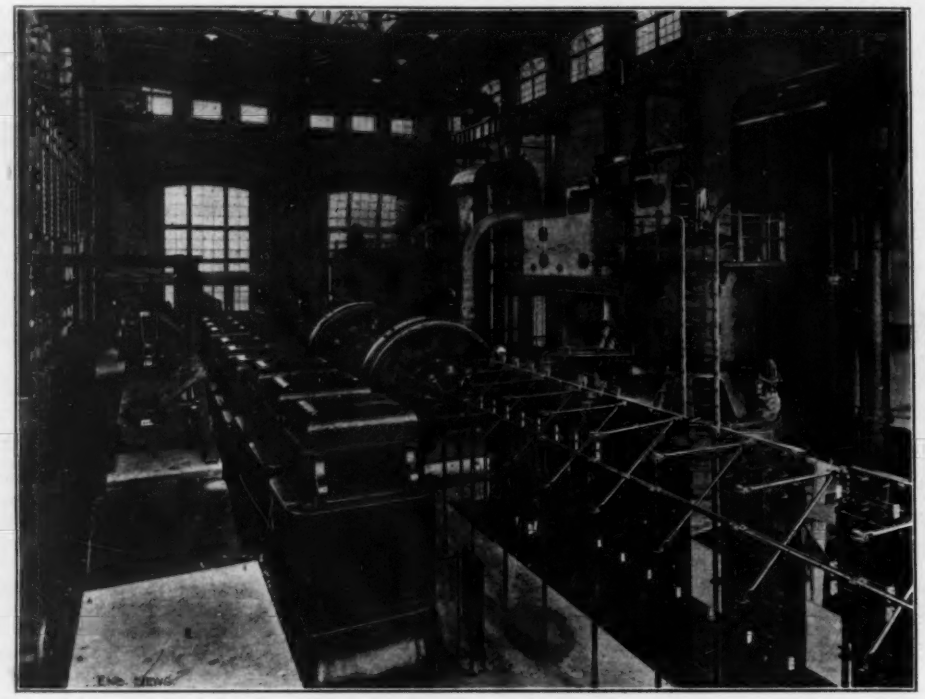


FIG. 4. VIEW OF INTERIOR OF POWER-HOUSE.

At all stations and in the Atlantic City and Camden yards, the third-rail is protected by a wooden guard (see Figs. 8 and 9). This consists of a 2-in. plank carried on castings attached to the top of maple posts which are secured to the third-rail at intervals of about 6 ft. The top casting is of such form that although it is provided with a web for strength no part of it extends either above or below the protection plank. Opposite all platforms the rail is further protected by a plank fastened to the side of the rail.

Wherever possible, the rail is kept between the tracks, and is therefore on the side of the track farthest from the station platform, and intertrack fences are provided to prevent crossing the tracks. In order to prevent passengers or others on the station platforms from touching the contact shoes on the platform side of the car, there is a protecting plank similar to the third-rail protecting plank but carried on castings fastened to the ties. The shoes are at all times under this plank and therefore protected. This device is used at all stations, even where the third-rail gives way to the trolley, although there is a switch on the car switchboard which enables the contact shoes to be cut out when operating from the trolley.

Where the third-rail terminates, as at street crossings, etc., a cast-iron approach block is used, whose top face is of suitable inclination to guide the contact-shoe.

The third-rail is bonded with concealed ribbon bonds with solid copper terminals compressed into 1-in. drilled holes in the rail. There are two bonds to a joint, and each has an area of 500,000 c. m., giving a total area of copper per third-rail joint equal to 1,000,000 c. m. The work of bonding the third-rail was accomplished at the rate of 660 bonds per day.

The third-rail jumpers, used to give electrical connection across crossings and other breaks in the third-rail, are of special design, illustrated in Fig. 7. The connecting cable is drawn into a tube of block bituminized fiber, and is laid in a solid concrete duct. At the end of the duct the concrete is carried up about 8 ins. above the ground line, whence an insulated connector clamped to the projecting end of the cable leads to the web of the third-rail. A terra-cotta cap covers the top of the duct structure. Both single and double jumper ducts of this kind were used, that shown in Fig. 7 being a double one. Several of these concrete jumper boxes may be seen in Figs. 9 and 10.

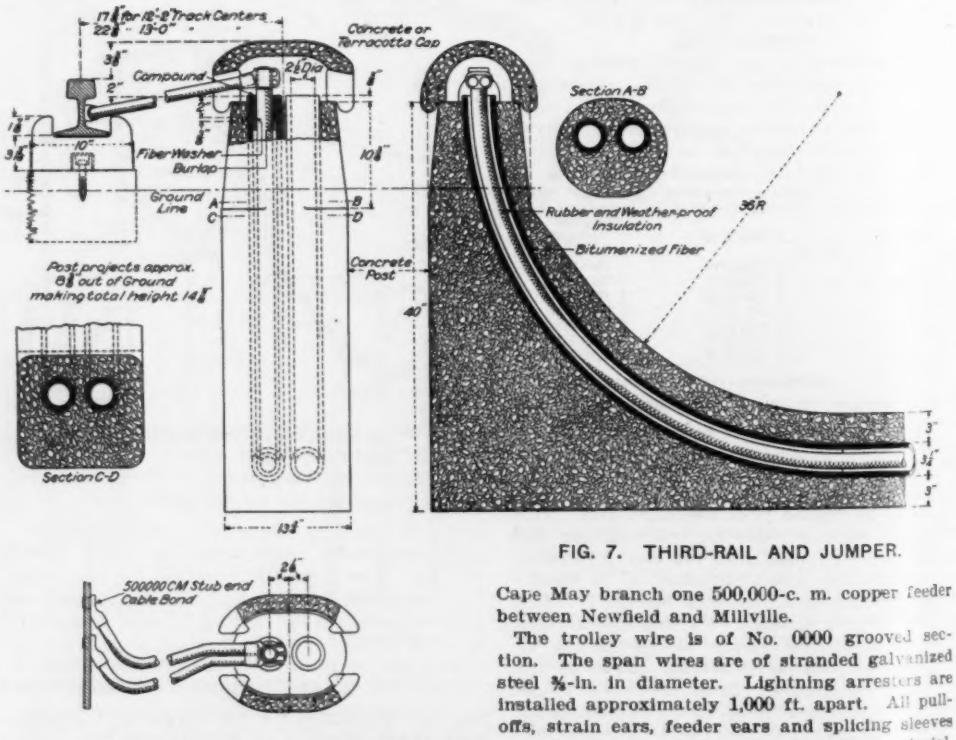


FIG. 7. THIRD-RAIL AND JUMPER.

The railway right-of-way is fenced in; at all crossings the fence turns in from the property line to the track, and the roadbed is protected by Climax cattle-guards between these fences (Fig. 8). As the third-rail terminates at the far end of the cattle-guards, the public is kept away from the third-rail altogether.

At Atlantic City, where the tracks cross the Thoroughfare, a new drawbridge has been built. The third-rails on this draw are connected to the third-rails on the approaches by sliding contact shoes, so that when the draw is closed the rail is continuously connected. In addition to this, two 1,000,000-c. m. submarine cables are provided connecting the rails so that the opening of the draw does not interrupt the circuit. The submarine cables for the return circuit are bare.

A point of great interest is to be found in the fact that the third-rail system has been adopted at both terminal stations where there are a number of platforms. This decision was made because it was thought that the difficulties of installation would be smaller than those to be expected with overhead trolley construction.

The third-rails of the two tracks are normally in electrical connection, so that the current flowing to a point on either rail has the combined conductivity of both. The connection is made midway between adjacent substations, and in the connector is a switch and fuse, mounted in a closed box. By this switch the two tracks may be isolated from each other when the necessity arises, as in case of an accident to the conductor system of one track. The third-rails are broken, moreover, opposite each substation, so that in case of an accident only a short section of conductor-rail needs to be cut out. The current supply to the third-rail is by direct connection at the substations only, no feeders being used.

The trolley construction (between Newfield and Millville and on the stretch of track between Haddon Ave. and South Gloucester) is of the span type, with poles spaced 100 ft. apart. Where practicable the high-tension transmission poles have been used for supporting the span wires. Through Camden the greater part of the trolley construction is on tubular steel poles. The trolley wire is supplemented by two 750,000-c. m. feeders from South Camden to Haddon Ave., and one 750,000-c. m. feeder running from South Camden to Brown's Crossing; and on the Cape May branch one 500,000-c. m. copper feeder between Newfield and Millville.

The trolley wire is of No. 0000 grooved section. The span wires are of stranded galvanized steel ⅜-in. in diameter. Lightning arresters are installed approximately 1,000 ft. apart. All pull-offs, strain ears, feeder ears and splicing sleeves are of bronze, and like all other line material, such as frogs, etc., are of standard pattern.

The work of bonding the track for the return current was a work of great difficulty on the main line, where a heavy steam-train traffic was in progress during the entire construction work.

At each joint two bonds of the concealed type, equivalent to 400,000 c. m. each, were used. On account of the large size of the bonds special angle-plates had to be provided. The holes, 1-in., were all drilled by hand. Almost all of this work was done by untrained labor under skilled foremen. The men were given a royalty of 5 cts. on each hole drilled above 30 per day, and some reached as high a maximum as 80 in a day's work. The railroad company required that one splice bar should always be kept in place against the rail to provide for the safe operation of the passing trains. The bond terminals were expanded in the holes by means of screw compressors.

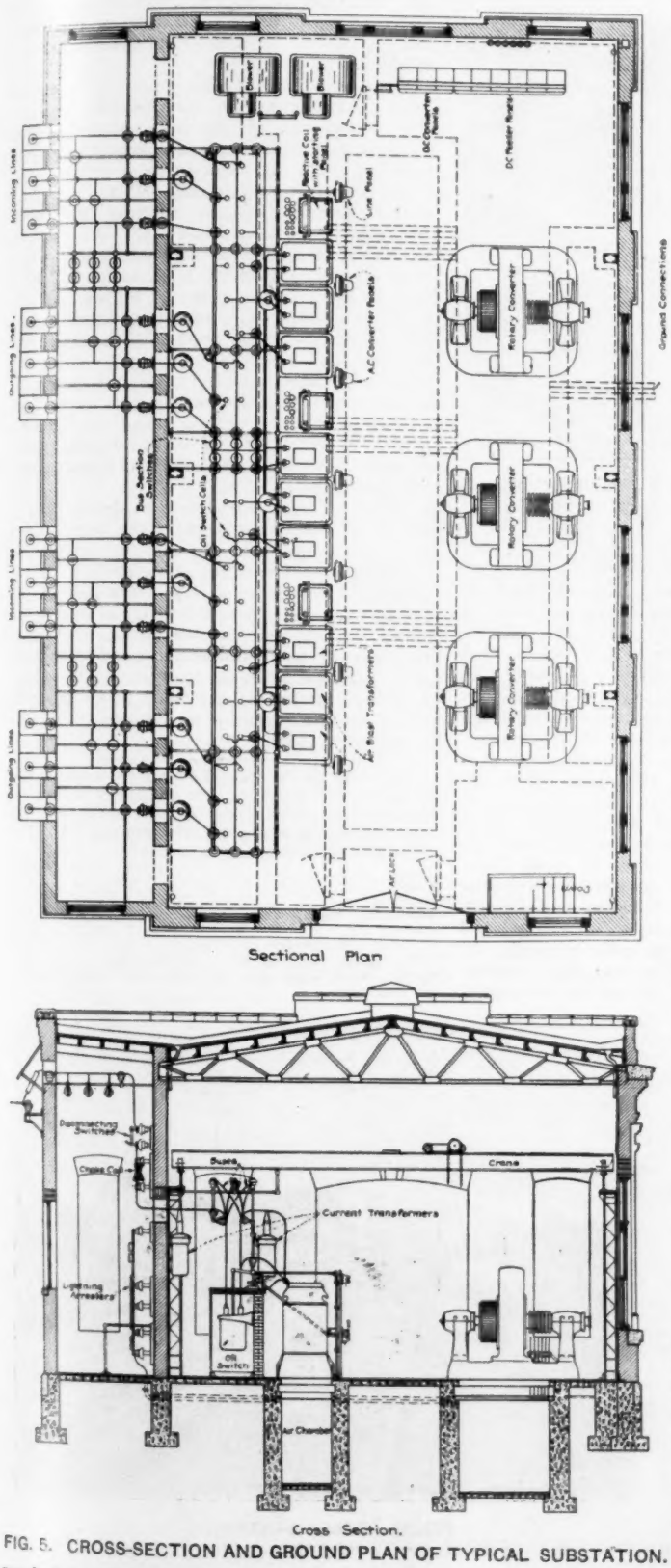


FIG. 5. CROSS-SECTION AND GROUND PLAN OF TYPICAL SUBSTATION.

CARS.

The cars for the electric service were specially designed and built for the purpose. They pattern closely after the standard Pennsylvania R. R. passenger coach, but were made somewhat lower to decrease the weight, have a roof of different shape, and are finished with mahogany in place of the standard oak interior finish. All cars are motor cars, carrying two 200-HP. motors (G E 69) on one of the two trucks, the other truck being a trailer. They have identical motor control and brake equipments. The control is of the Sprague-General Electric multiple-unit type. At present the rolling stock comprises 68 cars, of which 62 are vestibuled passenger cars each seating 58 persons, and 6 are combination baggage and mail cars.

The combination baggage and mail cars comprise a mail compartment 20 ft. long and a baggage compartment 29 ft. 9¼ ins. long inside.

The floor framing of the cars consists of 5 × 8 11/16-in. yellow-pine side sills and 7-in. I-beam intermediate and center sills. These are floored with two layers of tongue-and-grooved flooring laid diagonally, with ⅛-in. asbestos between; the top layer is maple. A continuous fireproof protection of ¼-in. "Transite" covers the under surface of the car, and over the motor truck a steel plate on asbestos fire felt is used.

The trucks are of the M. C. B. double side-bar equalized type, of 7-ft. wheel-base. The motor truck, complete, but without motors, weighs 14,934 lbs., and the trailer truck 9,653 lbs.

The wheels are 36 ins. diameter on the motor truck and 33 ins. on the trailer truck. The former have cast-steel spoke centers, on which a steel tire 3 ins. thick is shrunk and bolted. The hub of one wheel on either side of the truck is extended inward to form a gear seat; the gear is of forged steel and is shrunk in place after the wheel has been pressed on the axle. The motor truck axles are 7 ins. between wheels, 8 ins. at the wheel-fit and 5 ins. at the journal (5 × 9 ins.), finished all over. The trailing-truck wheels are solid rolled steel wheels (Schoen); their axles are 5¾ ins. at the wheel-fit and taper to 4¾ ins. diameter at the center, while the journals are 4¼ × 8 ins. The journal-boxes are of the Symington M. C. B. type.

The six baggage and mail cars and 22 of the passenger cars were built by the Wason Mfg. Co., of Springfield, Mass., 18 cars by the J. G. Brill Co., of Philadelphia, Pa., and 22 by the American Car & Foundry Co., of Wilmington, Del. The trucks for 65 of the cars were built by the Baldwin Locomotive Works, of Philadelph, Pa., and those for three cars by the J. G. Brill Co., of the same city.

GENERAL DIMENSIONS OF ELECTRIC MOTOR CARS.

Length over buffers	55 ft. 5½ ins.
Length over body end sills	46 ft. 6 ins.
Center to center of needle beams	10 ft. 6 ins.
Truck centers	33 ft. 0 ins.
Width over side sills	9 ft. 8¾ ins.
Width over sheathing	9 ft. 10 ins.
Width over window sills	10 ft. 0 ins.
Width over eaves	10 ft. 1¼ ins.
Height from under-side of center sill to top of roof	9 ft. 8½ ins.
Height from under-side of center sill to top of rail (car light)	3 ft. 7 5/16 ins.
Height from top of rail to top of roof (car light)	13 ft. 3 13/16 ins.
Height from top of rail to top of trolley wheel when hooked down on roof	14 ft. 8½ ins.
Total weight of car, fully equipped, on track	89,000 lbs.

The motors—two 200-HP. motors per car—and the Sprague-General Electric multiple-unit control system are of standard type, and require no detailed description. As is usual in heavy traction equipments, the controller handle is so arranged that the supply current is cut off and the brakes automatically applied if the motorman should release his hold of the controller handle. The controller and other motorman's apparatus are located in the front wall of the vestibule at one end of the car. The disposition is such that the front vestibule door, when opened, covers and encloses this apparatus. At this end of the car, also, is located a switchboard on which are mounted the headlight and air-compressor switches and fuses, the switches for cutting out the trolleys and the contact-shoes separately, and the current-limiting relay. This switchboard is accessible from the vestibule by double steel doors lined with asbestos.

Two wheel-trolleys and two contact-shoes are fitted to each car. Both trolleys have retrievers. The lightning arrester, the trolley cut-out switch and the trolley fuse are in a box set on the roof between the trolley bases. Steps on the vestibule corner posts, grab irons and roof-platforms facilitate access to the roof. The contact-shoes are carried on maple beams which are supported from the notched face of the extended equalizer spring seats, the notches allowing for adjustment in height.

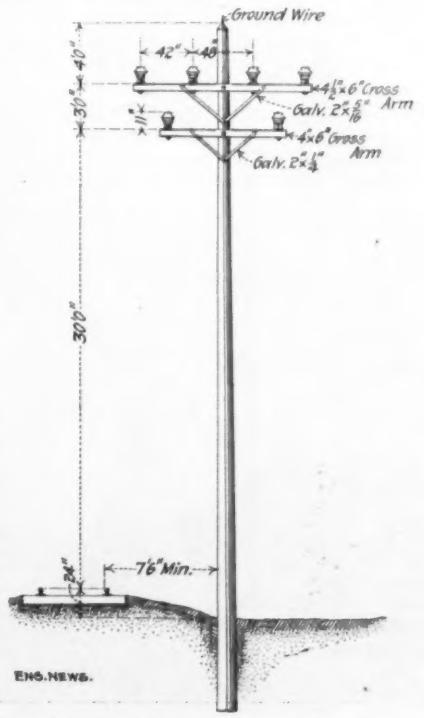


Fig. 6. Transmission-Line Pole; 33,000-Volt, Three-Phase Alternating Current Distribution.

The electrical equipment includes, further: the motor-driven air-compressor and its governor;

at each end a 50-c. p. incandescent electric headlight and two electric markers or route lamps; lamps for illumination comprising five 5-light clusters in the car, one lamp in the saloon and two lights in either vestibule mounted one over each vestibule trap-door; and 28 Gold cylindrical electric heaters, one under each seat. The heaters have two coils each, adapted to be connected so as to give three gradations of heating. The lamps in the central panel of the car are in the headlight circuit, which is controlled by a switch on the motorman's switchboard and is closed only on the leading car of the train. The glass sides of the middle panel carry the car number, which thus is illuminated only on the leading car.

All the electric cables are run in grounded "loricated" conduit, whose outlets are bushed with rubber-lined bell-mouths. All circuits were tested with high-potential alternating current after installation. The lamp wiring is carried in galvanized iron conduit on the roof of the car carried into the car through special roof-plates laid in lead.

The cars are equipped with hand brakes and with Westinghouse quick service automatic air brakes, Schedule "AMT." This brake schedule includes the brake valve, brake cylinder, triple valve, feed valve for reducing main reservoir pressure to 70 lbs., the brake pipe for train line, switches, gages, reservoirs, etc., together with what is known as the control line. This line extends through the train, and, besides insuring uniform pump labor on all cars, provides, in connection with the other apparatus, for the graduated release. The motorman is able to divide the process of release into as many steps as may be desired, securing the same flexibility as with straight air.

The quick recharge feature automatically maintains the auxiliary reservoir pressure through three separate feed ports so that any number of brake applications can be made in quick succession without depleting the system. It also includes a quick-service feature so that in service applications communication is established between the brake-cylinder and brake-pipe pressure, which materially assists the auxiliary reservoir to build up brake-cylinder pressure in the ordinary manner.

The brakes on both motor and trailer trucks are inside-hung. On the motor truck the brakes are hung from cast brackets riveted to the transom. The connection between the live lever and the crescent bar is by means of links straddling the wheels. On the trailer truck the brakes are hung from angles thrown across from the truck side-frames, and the Davis brake beam is used.

FIG 8. VIEW OF TRACK AT A CROSSING, SHOWING CATTLE-GUARD, THIRD-RAIL AND APPROACH, AND TOP AND SIDE PROTECTION OF THIRD-RAIL.

INSPECTION SHEDS.

Inspection sheds have been built at the three terminals. The largest one is on the dock at Camden, just back of the new passenger terminal. This is a three-track shed 221 ft. long by 56 ft. wide, accommodating nine cars, with room for office, storeroom and small machine shop at the end opposite to the entrance. All tracks have pits provided with steam heating, electric lights and receptacles, and compressed air outlets for cleaning. The third-rail is not carried into the shed, overhead trolley being used instead. The center track has overhead hand operated crane, with runway extending into the machine shop. The building is of wood frame construction covered with corrugated galvanized iron, with four-ply slag roof, and is supplied with large windows and skylights. Kinnear steel rolling doors are used at the main entrance. At Atlantic City the shed is of the same general arrangement, but smaller. It is a two-track shed 80 ft. by 42 ft., with doors at both ends and so located that a train can be run through on either track and the cars inspected one at a time as they stand over the pits in the shed. This building is of wood frame covered on the outside with expanded metal plastered with cement. The shed at Millville has one track and is of sufficient length for one car, with space to work around a truck when run out at one end. The construction is generally similar to that used at Atlantic City.

In all of the sheds the track rail is carried on a stringer which makes the top of the rail 12 ins. above the floor level. All tracks in the sheds are provided with continuous pits 3 ft. 6 ins. deep from top of rail. This arrangement is laid out with special reference to the arrangement of control and brake apparatus on the underside of the car, and is very convenient for inspection.

The entire contract for the electric traction equipment described in the preceding, including the construction of the power-house and sub-stations and the electrical machinery and apparatus on the cars, was awarded to the General Electric Co., of Schenectady, N. Y. Mr. W. B. Potter, Engineer of the Railway Engineering Department, General Electric Co., was in direct charge of the electric equipment, assisted by Messrs. J. E. Hewes, C. E. Eveleth and W. H. Clapp. Stern & Silverman, of Philadelphia, Pa., were the general sub-contractors under the General Electric Co. The Scofield Company, of Philadelphia, Pa., acted as engineers for the power-house and sub-contractors for the piling and foundations. The interlocking plants and automatic signal work were installed by the Union Switch & Signal Co., of Swissvale, Pa., in accordance with plans of the Signal Department of the Pennsylvania R. R.

The new cars and trucks were designed by the Motive Power Department of the railroad company. All grading, changes in tracks, new bridges, double-tracking, construction of terminals and inspection sheds, changes in telegraph lines, and installation of a special telephone system, were carried out by the regular Engineering and Maintenance-of-Way Departments of the railroad company. The electric work was carried out according to the plans and under the supervision of Mr. George Gibbs, Chief Engineer of Electric Traction.

THE COST OF CONCENTRATING Butte ores is given by Mr. C. W. Goodale, General Manager of the Boston & Montana Consolidated Copper & Silver Mining Co., in an address delivered before the '06 graduating class of the Colorado Schools of Mines, as follows:

Labor	$0.30
Power	.10
Supplies	.08
Insurance, management, etc.	.02
Total cost per ton	$0.50

The power required to concentrate one ton of ore is ½-HP., while 7,680 gals. of water are required per ton of ore.

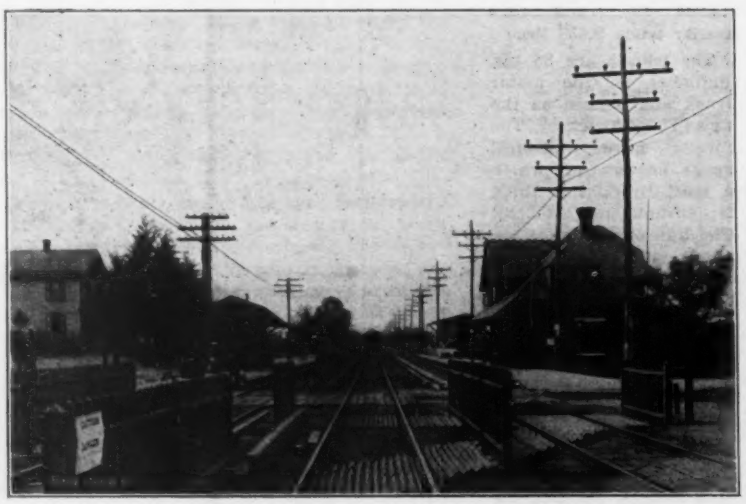


FIG. 9. WESTVILLE STATION.

FIG. 10. REEGA STATION.

FIGS. 9 AND 10. VIEWS AT STATIONS, SHOWING ARRANGEMENT OF THIRD-RAIL.

The average analysis of Butte ores is given as follows:

SiO_2	54.5%
Al_2O_3	10.1%
Fe	10.9%
S	13.9%
Cu	4.14%
Ag	1.68 oz.
Au	0.0127 oz.

The maximum size of particles used in concentrating is 1/32-in.

A NEW HORIZONTAL BOILER RIVETER INSTALLATION.

As is well known, the usual style of riveter employed in the boiler shops of this country, is a vertically set machine, with crane, steel tower, electric hoist, etc. In Germany, however, riveters suspended horizontally from trestles are much in use, and it is this latter style of apparatus, now being placed on the market in this country, that this article will describe.

The complete installation, a general view of which is shown in Fig. 1, consists of a steel trestle built up of standard channels, angles, etc., a 10 ft. 6 in. gap compression riveter, suspended horizontally from the trestle by a hand crane, and a truck for carrying the boiler during the riveting. As is shown by Fig. 2, the compression riveter is balanced against a counterweight, in order that the riverter may be easily raised or lowered by the hand crane. The truck is provided with a sprocket wheel and chain drive for moving it towards or away from the riveter. This movement is accomplished by placing a piece of small pipe on a tooth of the sprocket wheel and using it for a crank to rotate the sprocket. On top of the truck will be seen six small rollers, upon which the boiler rests when ready for riveting. These rollers are so arranged that the boiler may be rotated about its horizontal axis, thereby making it possible to bring any part of its circumference under the riveting die. Fig. 2 also gives further details of this new design and shows the arrangements of parts.

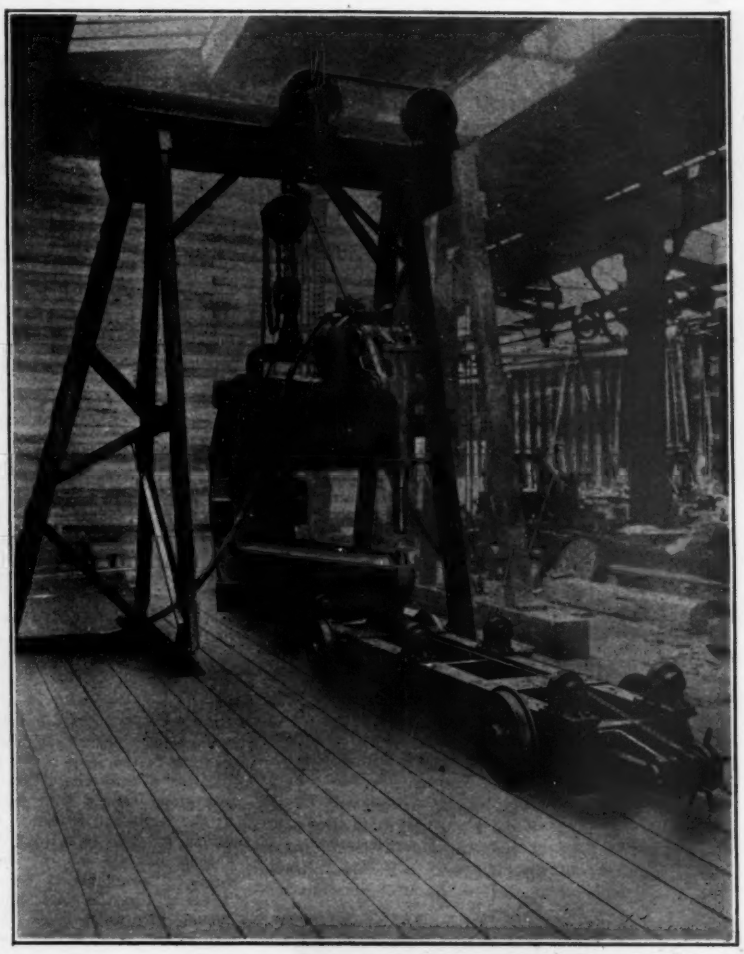


FIG. 1. A LARGE HORIZONTAL RIVETER INSTALLATION.
Chester B. Albree Iron Works Co., Allegheny, Pa., Builders.

While the space saved by installing this style of apparatus may, in many cases, be important, nevertheless the thing that will doubtless appeal to most users of this class of apparatus will be the saving made in the cost of the initial installation and its operation after being installed. It is the claim of the manufacturers that this style of apparatus can be installed for one-half the price of a vertical, stationary, air compression riveter and one-quarter the cost of a vertical hydraulic installation, size and power being equal. The cost of a horizontal and a vertical pneumatic installation is given by the manufacturers as follows:

COST OF A HORIZONTAL PNEUMATIC INSTALLATION.

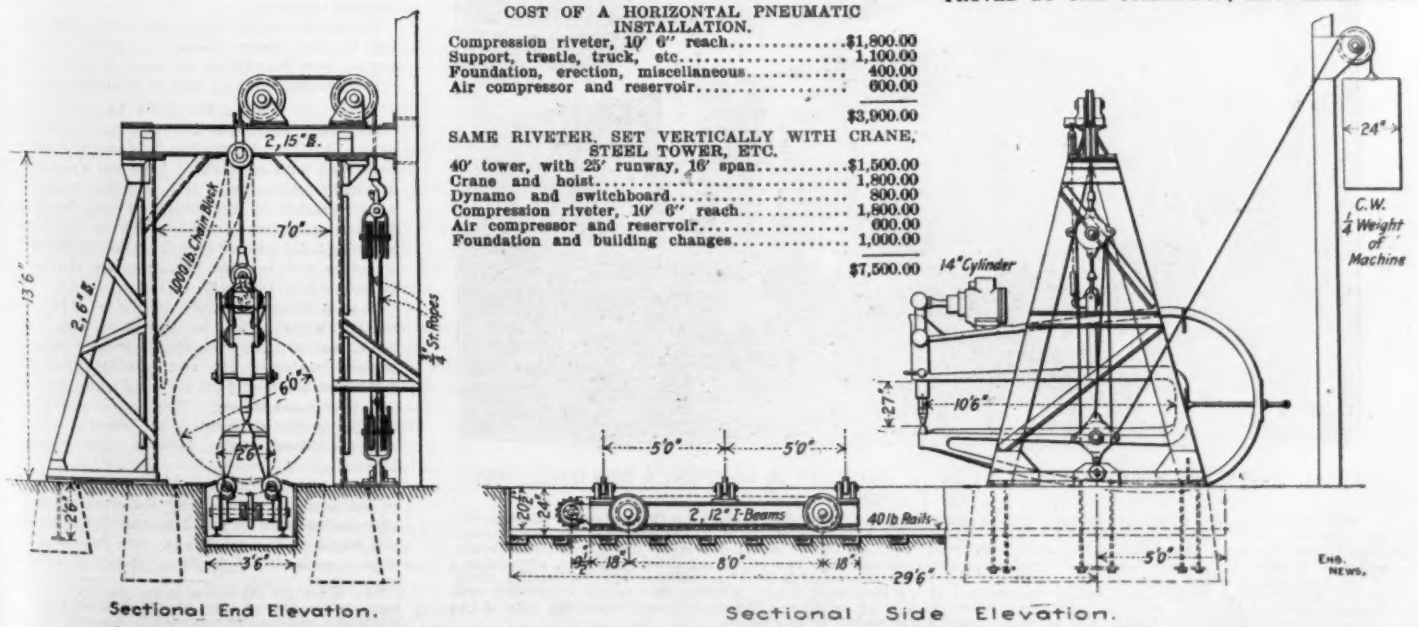
Compression riveter, 10′ 6″ reach	$1,800.00
Support, trestle, truck, etc.	1,100.00
Foundation, erection, miscellaneous	400.00
Air compressor and reservoir	600.00
	$3,900.00

SAME RIVETER, SET VERTICALLY WITH CRANE, STEEL TOWER, ETC.

40′ tower, with 25′ runway, 16′ span	$1,500.00
Crane and hoist	1,800.00
Dynamo and switchboard	800.00
Compression riveter, 10′ 6″ reach	1,800.00
Air compressor and reservoir	600.00
Foundation and building changes	1,000.00
	$7,500.00

The cost of operating these pneumatic machines is said to be about one-fifth that of a corresponding hydraulic riveter, since the power required to drive them is about one-fifth that required to drive the hydraulic machine.

The installation here described was designed and built by the Chester B. Albree Iron Works Co., of Allegheny, Pa., for a boiler shop, and will rivet a boiler 6 ft. in diameter, with plates up to 10 ft. 6 in. in length. The apparatus is, however, equally well adapted for tank or structural steel work.



Sectional End Elevation. Sectional Side Elevation.

FIG. 2. SIDE AND END ELEVATIONS OF A HORIZONTAL BOILER RIVETER INSTALLATION.

CHANGES IN THE FORM OF THE CONTRACT FOR COMPLETING THE PANAMA CANAL.

Some important changes in the contract for completing the Panama Canal are called to the attention of intending bidders in the following circular just issued by Mr. T. P. Shonts, Chairman of the Panama Canal Commission. The original form of contract, practically in full, was published in our issue of Oct. 18, 1906.

Bidders are hereby notified that the form of contract for the completion of the construction of the Panama Canal attached to and required to be made a part of the proposal for the completion of the construction of said Canal under the invitation of the Isthmian Canal Commission issued Oct. 9, 1906, is modified in the following particulars, by the addition of the words printed in capitals and enclosed brackets:

ARTICLE III.

8. Transportation of the Contractor's employees, employees' families, and supplies over the Panama Railroad and [EMPLOYEES AND EMPLOYEES' FAMILIES OVER] its Steamship Lines at rates not greater than one-half the regular published tariff rates.

ARTICLE VI.

10. He shall, [SUBJECT TO SUCH INDEMNITY AS IS PROVIDED FOR IN ARTICLE VII.,] assume and be responsible for all just legal claims for injuries or wrongs inflicted upon persons and property by his own act or that of any of his employees, except property and land damages necessarily occasioned by the orderly construction of the Canal and auxiliary works.

ARTICLE VII.

1. Payments will be made to the Contractor by the Commission on or about the fifteenth day of each month in current coin of the United States or its equivalent, either in Panama, Washington, or New York City, as the Contractor may elect, covering the cost of the actual construction work done by the Contractor or his subcontractors upon the Canal during the preceding calendar month, including therein labor cost, superintendence, and clerical service on the Isthmus, transportation of workmen to the Isthmus, overtime paid to employees, wages paid to employees when sick, if allowed by the Chief Engineer, current purchases of tools and repairs made by the Contractor, and the actual cost to the Contractor of any materials put into the work; and excluding the cost of organization, administration, legal and general expenses of the Contractor, interest, taxes, cable service, commissary purchases and the cost of running the mess houses, should the Contractor take over the same, and all expenses to which he shall have been put by reason of his own negligence or inefficiency, or by reason of the supply of any unsound or imperfect materials rejected by the Chief Engineer or any imperfect preparation or use of material, and all expenses not directly connected with the construction work which he may have incurred on his own account: [PROVIDED, HOWEVER, THAT TWO-THIRDS OF THE ACTUAL COST TO THE CONTRACTOR OR SUBCONTRACTORS OF MEETING VALID LEGAL CLAIMS OF EMPLOYEES OR OTHERS FOR DAMAGES FOR INJURY OR DEATH DUE TO THE ACTUAL WORK OF CANAL CONSTRUCTION, OR OF COMPROMISING, WHEN APPROVED BY THE COMMISSION, ANY CLAIMS FOR

SUCH DAMAGES SHALL BE INCLUDED IN THE MONTHLY PAYMENTS ABOVE PROVIDED FOR.

ARTICLE VIII.

2. If the construction work upon the Canal proper herein provided for shall not be completed by the Contractor within the time fixed by the Engineering Committee, the Contractor shall forfeit as liquidated damages for each month that the work of construction shall exceed the estimated time for the construction one hundred thousand ($100,000) dollars; if it shall be completed by him in less time, he shall be paid a premium of one hundred thousand ($100,000) dollars, in addition to all other compensation earned hereunder, for each month less than the estimated time in which he shall have completed it: [PROVIDED, HOWEVER, THAT THE DAMAGES ASSESSED UNDER THIS SECTION SHALL NOT IN ANY EVENT EXCEED THE PERCENTAGE OTHERWISE PAYABLE TO THE CONTRACTOR AND THE AMOUNT OF THE CONTRACTOR'S BOND TO SECURE PERFORMANCE.]

3. If, however, at the end of any year of the Contractor's work, [OR AT THE OPTION OF THE CHIEF ENGINEER AT THE END OF ANY SHORTER PERIOD,] the cost of construction has not exceeded nor the rate fallen below the proportionate estimated cost or rate of construction, the Commission will pay to the Contractor two-thirds of the agreed percentage upon the actual cost to such date.

ARTICLE IX.

4. If, at any future time, the plans and specifications for the construction of the Canal, as submitted to the said Engineering Committee, shall be materially altered in any respect, the said Committee, or a new Committee formed in the same manner as the original Committee, shall, upon [WRITTEN] notice of either the Commission or Contractor, [GIVEN WITHIN SIXTY (60) DAYS.] promptly convene, and modify the original estimate as to the cost or time, or both, by adding to or taking therefrom the additional cost or time fairly attributable to the changes made in said plans and specifications. [IN THE ABSENCE OF SUCH WRITTEN NOTICE EXISTING ESTIMATES SHALL STAND UNCHANGED.]

Some of the reasons for making the changes indicated are, in brief, as follows:

Article III.—In refusing to take the contractor's supplies at half rate over the steamship lines, the Government removes all ground for the charge that the Government is showing favoritism by bringing traffic to New York and to its own steamship lines. As a matter of fact, the contractor will have very few supplies to transport, as the Government will furnish and transport everything not pertaining directly to the organization of the contractor's own offices.

Article VII.—The Government assumes two-thirds of the accident liability, because it has transpired that the insurance companies are placing enormous premiums on accident liability policies on the canal, and the natural effect would be to make the contractor increase his percentage in order to meet them. When it is known that the Government will bear two-thirds of these losses, the premiums should fall to a reasonable figure. The truth is, that the laws concerning Employers' liability on the isthmus are so few and unimportant that neither the contractor nor the Government will have many claims to meet, even in case of serious accidents.

Article VIII.—It was shown in Engineering News of Oct. 18 that the contractor runs very little risk of loss through errors in the estimates of the cost of his work, since the premium he receives for work done below the estimate is three times as large as the penalty he pays for work done in excess of the estimate. Some prospective bidders have urged, however, that if the Engineering Committee should make a very gross error in fixing the time necessary for completion, underestimating it by several years perhaps, then the contractor might have to lose a very large amount. To meet this objection the Government has limited the contractor's liability under this clause to the amount of his earned profits plus his indemnity bond of $3,000,000.

REINFORCED CONCRETE IN THE SAN FRANCISCO FIRE: THE JOHNSON BUILDING.

In our issue of Sept. 27 we discussed Mr. A. L. A. Himmelwright's recent monograph on the San Francisco fire, and particularly his references to the behavior of reinforced concrete. As our readers will remember, Mr. Himmelwright as a result of his investigations at San Francisco claimed that reinforced concrete in the form of beams or girders was unsuitable to resist fire on account of the heating and weakening of the reinforcing rods on the under side of the beams.

The most notable example cited by Mr. Himmelwright in support of his argument against reinforced concrete beams was the Johnson & Co. building, at 122 First St. We are now in receipt of a very interesting letter from Mr. C. F. Wieland, M. Am. Soc. M. E., Consulting Engineer of San Francisco, in which the claim is made that the reinforced concrete in the Johnson Building was so defective in design that its failure should not be charged at all to reinforced concrete construction generally.

In order that a fair comparison may be made by the reader, we print below Mr. Himmelwright's statement concerning the Johnson Building, together with one of his photographs, as published in his book, and follow it by Mr. Wieland's letter:

(From Mr. Himmelwright's Book.)

JOHNSON CO. BUILDING,
N. W. Cor. Minna and First Streets.
Albert Farr, Architect. J. C. Johnson & Co., Owners.

DETAILS OF CONSTRUCTION:

This was a five-story structure, and was occupied and used by the owners as a store for harness and leather goods. The facades consisted of buff terra cotta and pressed brick.

The walls are self-supporting. The columns are of cast iron, spaced about 16½ ft. centers, and are unprotected. The steel girders are set the north and south way in the building and have the soffits exposed. The floors between girders are of the reinforced concrete type, the floor slab of stone concrete, 4 ins. thick, being supported by three reinforced concrete beams about 5 ft. c. to c. in each bay. The floor slab is generally reinforced by ¼-in. wire strands of seven wires each, spaced 16 ins. apart in the direction parallel with the reinforced beams and 8 ins. apart crosswise with the beams. In some cases heavy twisted strands, heavy wire, rods, etc., are used. The reinforced beams are about 12 ins. deep, and 1-in. diameter round rods are imbedded in them an inch from the under side, where the beams are 5 ins. in width. The rods are threaded at the ends and anchored to the girders through holes punched in the webs. The floors were finished in wood, and the cinder sleeper fill 2½ ins. thick is reinforced at the under side with No. 16 hexagonal mesh poultry netting.

EFFECTS OF THE FIRE AND THE EARTHQUAKE:

The whole upper portion of the walls above the fourth floor level fell inward. The First St. side, the N. W. L. extension and two bays in the middle portion of the building have collapsed and fallen into the basement, a number of beams, girders, rods, etc., in a tangled mass, hanging to the sides of the portions yet standing. Those portions of the fronts that remain standing are in bad condition. There is a decided break in the masonry at the southeast corner at the second floor level. The Minna St. front is out of plumb 3½ ins. at the southeast corner and 1¼ ins. at the southwest corner, leaning south. The northeast corner leans north about 1 in. The levels on the water table show that the foundations remain practically level. In the basement where there are evidences of a very hot fire, such as fused copper, light castings, nails, etc., indicating a temperature of about 2,200° F., the reinforced concrete beams failed, and the soffits of the girders being exposed, they deflected badly. There was no load on the floors above, so that the deflections and failures were caused solely by the heat below.

COMMENTS:

The upper portions of the walls were probably shaken down by the earthquake, which no doubt is responsible for the failure of the upper part of the building. The collapse of the N. W. L. extension and of the two bays in the middle portion of the building is probably due to the failure of the reinforced concrete beams or of the exposed columns.

Where the metal frame and walls are yet standing, the concrete floors remain in place, but considerably sagged, and the girders are more or less deflected.

The foundations only can be utilized in rebuilding.

(Mr. Wieland's Letter.)

Sir: Your comments in your issue of Sept. 27, p. 333, on Mr. A. L. A. Himmelwright's recent publication, have been read with interest. I have not seen a copy of Mr. Himmelwright's book and therefore only infer from your remarks, my examination of the building after the fire and again since your article appeared, that Mr. Himmelwright did not analyze the constructive details of the structure and by that finding place the blame for the failure where it justly belonged.

The building was of composite type, stock brick bearing walls with 4-in. facing of thin or Milwaukee brick, cast-iron columns, steel I-beam girders and column beams, reinforced (?) rock concrete floor beams and reinforced (?) rock concrete floor slabs with some cinder fill under wood topping. The nailing strips for the wood flooring projected about ¼-in. above the concrete slab and the 16-in. spaces between strips were somewhat concave.

The basement girders were not supported on brick piers as indicated in your article* but were on, and connected very inadequately to guard against earthquake movement, full length cast-iron columns. The basement height from floor to underside of the 24-in. girders is about 7 ft. The

*We made the statement from the evidence of the photograph reproduced from Mr. Himmelwright's book. Mr. Wieland's explanation makes the construction clear.—Ed.

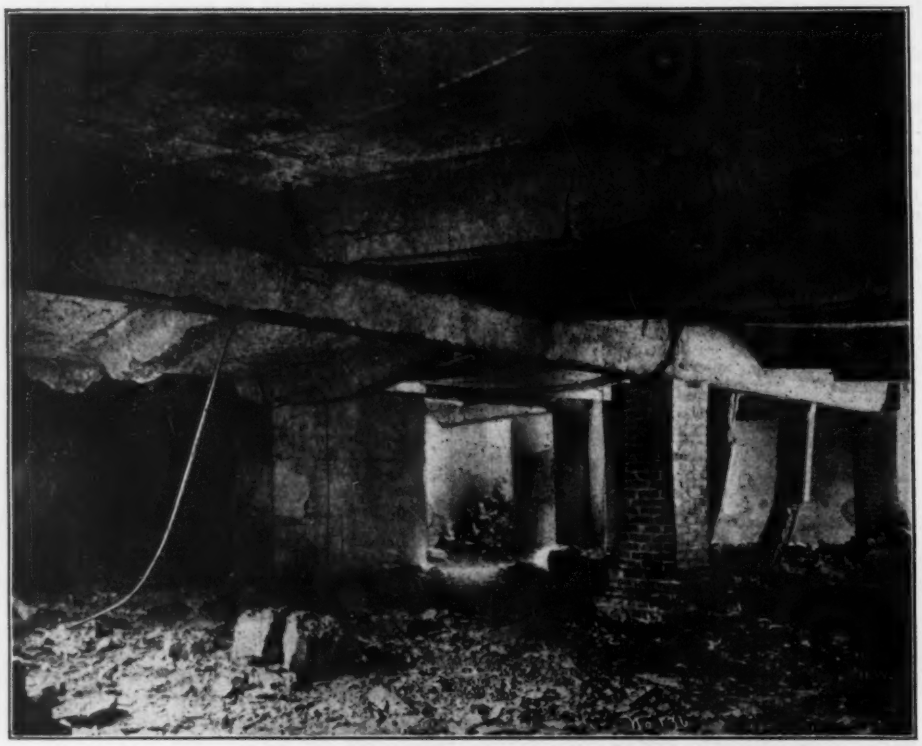


FIG. 1. (FROM MR. HIMMELWRIGHT'S BOOK.) JOHNSON & COMPANY'S BUILDING. BASEMENT STORY.

Showing the failure of the reinforced concrete beams. There was no load resting on the section of the concrete floors shown. A hot fire in the basement, which contained the hardware stock of a harness and leather concern, caused the damage. The floor slab with reinforced concrete beams, where the latter did not fail completely, deflected as much as 12 ins. between the girders in some places. The two reinforced concrete beams, which failed in the rear, are hanging down at the right-hand side. The floor slab is still in position, but has sagged about 18 ins. at the center of the span. Note the sections of the reinforced concrete beams that failed, at the left, still clinging to the floor slab. From a positon a little to the left of where the photograph was taken, the rods of the nearest reinforced concrete beams can be seen crossing the cracks in the concrete.

basement columns were encased in pressed brick laid up 22 ins. square around some columns, with rectangular shapes, and in other instances 22 ins. round with segmental bricks. All of the basement columns are available in place at this day for inspection.

Technical publications are often consulted by the

FIG. 2. PHOTOGRAPH OF FIRST FLOOR GIRDER, BEAMS AND FLOOR PANEL OF JOHNSON BUILDING; BY C. F. WIELAND, TAKEN OCT. 12, 1906.

layman seeking general information, but by training unable to weigh all phases of a subject as he finds it presented; therefore I express with the kindliest feeling the opinion that an engineer should be extremely careful as to facts; and to draw conclusions of such moment as Mr. Himmelwright attempted should only be done after painstaking examination and thorough analysis. When one may serve a good purpose by so doing there need be no hesitancy to declare against a dangerous design or misuse of good material.

The attempt at reinforced concrete construction in the Johnson building must have resulted from a bad dream—a nightmare, in fact. Consulting the blue-print mailed herewith (Fig. 3), showing a typical first floor panel, it will be seen that the entire sectional area of the concrete beam is 144 sq. ins. and that 112 sq. ins. thereof lies above the center of the solitary 1-in. round rod intended as reinforcing. The rod is without a bend in its length and lies with its center 4 ins. from bottom of beam and not 1 in. from the bottom as mentioned by you. All of the steel girders which I examined were punched the same distance from top of flange to receive the rod for the individual beams. The reinforcement must not be spoken of in the plural: there was but one rod used in each beam.

It is no surprise that the beam deflected when the reinforcing was so inadequate to the duty imposed upon it by a sub-panel area of about 80 sq. ft. of dead load at, say, 55 lbs., and a very moderately assumed live load of 150 lbs. for a store-room devoted to the handling of harness hardware and harness. In point of fact, some of the beams were braced up, before the fire, by truss rods, and these could be seen in the building before it was torn down. In the photograph I send (Fig. 2) will be seen one of the truss rods, with right and left-hand nut, extending up in the foreground at extreme right.

The photograph shows the under side of the typical panel of which the drawing (Fig. 3) was made, the long black streak immediately under the 24-in. girder (I-beam) being a folding rule which did not serve its 6-ft. purpose.

I send you by express samples of the concrete just as it was taken out of the building for purpose of this communication. I venture the opinion that if all concrete was of the character evidenced by the samples, no one could find fault, as a whole, with that type of construction. The sample with poultry netting in place is out of a floor slab. The sample of the beam has a piece of wire cable with only one wire imbedded therein.

One of the astonishing features in connection with this building is that a worn out street railway cable was unravelled and its constituent strands made to do duty (?) as reinforcement in the floor slab across the beams. It can readily be surmised that the snarly nature of the unravelled strands would forbid its being uniformly spaced and laid in place. Fair samples of the strands are sent you with the concrete and the worn and broken condition of the individual wires will be evident to you. There seemed to be no continuity to the strands. In some of the slabs it is difficult to locate any of the cable strands. None were found projecting from the fractured slab photographed. In full view in the slab are seen heterogeneous patches of plain light gage wire. On top of this wire the poultry netting was placed. Poultry netting is a satisfactory counter-resistant to

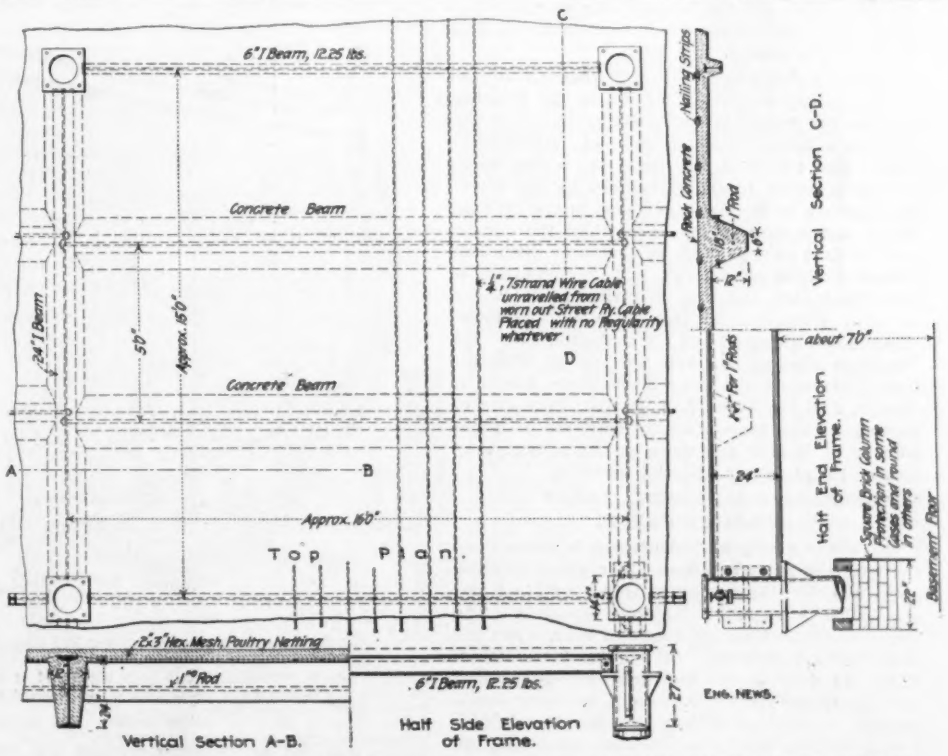


FIG. 3. PLAN AND SECTIONS OF A FIRST FLOOR PANEL OF JOHNSON BUILDING. DRAWN FROM DATA TAKEN ON THE PREMISES, OCT. 9, 1906, BY C. F. WIELAND.

Plymouth Rocks, but surely not to the kind under review, and it never was intended as a reinforcement for concrete, at least in warehouse floor construction.

In view of the fact that the worn-out strands of the cable and the poultry and the plain wire were all laid practically on the bottom of the floor slab, and in themselves were structurally of little value, it must be conceded that the rock concrete made a remarkably creditable showing. I took from the bottom of the photographed slab a piece of concrete and the poultry netting underlying it, and pieces of a short wood block converted by the heat into charcoal. The wood block was one of some pieces of 1-in. stuff laid directly on the poultry netting and apparently introduced into the slab as nailing pieces for a partition in the basement. The wood block was in direct contact with the wire and the piece of concrete. The concrete is not powdered and is covered with a bright black "japanning," such as results from the burning of timber rich in pitch.

To demonstrate that other features entering into the construction of this building were not properly treated I call your attention to the 6-in. steel I-beam (Fig. 3), weighing 12.25 lbs. per lin. ft., introduced as a floor beam between the cast-iron columns. The sub-panel meant to have been cared for by this steel beam was of same area as assigned to the concrete beams, namely, 5 ft. × 16 ft. = 80 sq. ft. In this discussion it is not worth while to cut out the column area to arrive at the actual load. The dead load on the beam may be summed up as follows:

	Lbs.
80 sq. ft. of 4-in. rock concrete in floor, at 50 lbs.	4,000
80 sq. ft. of cinder topping and wood floor, at 4 lbs.	320
Weight of rock concrete fireproofing of beam (none under soffit of beam)	300
Total dead load, except weight of beam	4,620

However, assuming the net length of beam to be 15 ft., it will be found that it is generally accepted as good for a load of 5,100 lbs. with a safety factor of 4, and that its deflection when uniformly loaded with 5,100 lbs. will be $^{17}/_{32}$-in. The dead load on the beams in the building is seen to have been 90% of the permissible safe load. As stated, for a store room devoted to the handling of harness and harness hardware it is reasonable to provide for a live load of at least 150 lbs. on the floor. As the 6-in. beam is already taking 90% of its safe capacity there remains but say 500 lbs. to care for the live load of 12,000 lbs. The 6-in. beams are secured (?) to the columns with a solitary ¾-in. bolt, and the 24-in. girders are provided with two ¾-in. bolts as column security. Is there any wonder that the structure may have moved during the earthquake, throwing the exterior brick veneering down in sheets? I find no evidence, in a wall area of 50 sq. ft., that the veneering was bonded into the backing.

The building was erected about five years ago, and I submit that no conclusion can be drawn from its behavior during earthquake and fire other than it was most unfortunately designed in respect to the features herein mentioned, and that the inspection department of the city did not realize the dangers embodied in the plans.

I have devoted time, urgently needed in other directions, for the discussion of this building, because of the publicity it has had through Mr. Himmelwright, and

in the hope that he will modify his conclusions as to the performance of reinforced concrete structures in San Francisco with respect to this one at least.

Very truly yours,

C. F. Wieland, M. Am. Soc. M. E.

Cor. 2d and Folsom Sts., San Francisco, Oct. 13, 1906.

The samples of concrete and of reinforcing material sent us by Mr. Wieland correspond closely with his statements. While the sagging beams in Mr. Himmelwright's photograph, Fig. 1, do look discouraging for reinforced concrete under severe fire tests, the character of construction as described by Mr. Wieland would seem to fully account for the sagging and failure. Undoubtedly a great deal of poor work in reinforced concrete construction has been done during the past few years and is being done now; but the failures and defects of such works ought not to be charged against reinforced concrete construction as a class. Flimsy work is done in steel and wood construction, but it argues nothing against the merits of steel and wood as building materials.

THE SLOW SAND FILTRATION PLANT FOR THE WATER SUPPLY OF WASHINGTON, D. C.

Since Oct. 5, 1905, the city of Washington, D. C., has been fully supplied with water from a 75,000,000-gal. slow sand filtration plant that is not only the largest water purification plant in the United States yet put in operation, but also contains some of the latest features of water filtration design. The plant and its operations for a number of months were described in great detail last night (Nov. 7, 1906) in a paper entitled "Works for the Purification of the Water Supply of Washington, D. C.," presented to the American Society of Civil Engineers. The paper was prepared by Mr. Allen Hazen, M. Am. Soc. C. E., of New York, who was the consulting engineer for the design and construction of the plant, and Mr. E. D. Hardy, M. Am. Soc. C. E., who has been connected with the plant since its inception, as first assistant engineer during construction and subsequently as superintendent of operation. We give below a description of the plant based on the paper just named (Proc. Am. Soc. C. E., Vol. XXXII., No. 6, September, 1906, pp. 586-642). All our illustrations except Fig. 2 have been reproduced from corresponding ones in the paper named.

Before proceeding with our abstract of the paper, it may be noted that one of the principal reasons for installing the Washington filters was the high typhoid death rate at Washington, which had prevailed for many years and which it was expected would be reduced by the filters. An increase instead of a decrease in the typhoid, more particularly in the cases than the deaths, for the first part of 1905 as compared with 1906 led to various allegations, widely circulated, to the effect that the new filtration plant was a failure. Elsewhere in this issue will be found reports on typhoid at Washington by Mr. Theodore Horton, M. Am. Soc. C. E., Consulting Engineer of the New York State Board of Health, and Dr. Wm. T. Sedgwick, Professor of Biology at the Massachusetts Institute of Technology. A further discussion of the subject may also be found in our editorial columns.

ABSTRACT OF MESSRS. HAZEN AND HARDY'S PAPER.

The water supply of Washington is taken from the Potomac River at Great Falls, about 14 miles above the city, through an aqueduct 9 ft. in diameter, with a slope of 9½ ins. per mile. The aqueduct is lined except where in rock, when the diameter is increased. At 9 miles below Great Falls the flow of the aqueduct passes through the Dalecarlia Reservoir, formed by damming a natural valley, and 12 miles below the falls it pasess through a second reservoir, known as the Georgetown. Until a few years ago the latter served as a distributing reservoir, but at present a second tunnel, about 4 miles long and generally 9. ft. in diameter, conveys water to the Washington City Reservoir, located within the city. The new tunnel is lined throughout and is a deep inverted siphon. Under Rock Creek the tunnel is 170 ft. below the hydraulic grade, and at this point it is lined with flanged cast-iron plates filled with concrete. The greater part of the original aqueduct is also lined.

The approximate full carrying capacity of the aqueduct is 75,000,000 gals. per day. The two older reservoirs have nominal storage capacities of 150,000,000 gals. each and the corresponding capacity of the new reservoir is 300,000,000 gals.; but for practical purposes the combined available capacity of the three reservoirs is 300,000,000 gals. The lower portions of the city are supplied by gravity and the higher portions by pumping to two high-service reservoirs.

QUALITY OF THE POTOMAC RIVER WATER.—The leading facts regarding population on the drainage area of the river are shown by Table I. The table and other facts regarding the river water are commented on by the authors of the paper, as follows:

TABLE I.—POPULATION ON THE DRAINAGE AREA (11,043 SQ. MILES) OF THE POTOMAC RIVER ABOVE GREAT FALLS.

Place.	State.	Aproxi. dist. above Great Falls, miles.	Population 1880.	1890.	1900.
Frederick	Md.	45	8,659	8,193	9,296
Hagerstown	Md.	70	6,627	10,118	13,591
Martinsburg	W. Va.	75	6,335	7,226	7,564
Waynesboro	Pa.	85	1,888	3,811	5,396
Winchester	Va.	100	4,958	5,196	5,161
Chambersburg	Pa.	115	6,877	7,863	8,864
Cumberland	Md.	155	16,693	12,729	17,128
Frostburg	Md.	165	.....	3,804	5,274
Staunton	Va.	175	6,664	6,975	7,289
Total population, towns above 4,000 inhabitants			52,701	65,915	79,563
Places having from 1,000 to 4,000 inhabitants			23,087	27,153	37,523
Rural population (being all the remainder)			384,664	405,155	420,007
Total population on water-shed			460,452	498,223	537,093
Population per sq. mile, places above 4,000 in 1900			4.7	5.9	7.2
Places having from 1,000 to 4,000 inhabitants in 1900			2.1	2.4	3.4
Rural population per sq. mile			34.9	36.8	38.0
Total population per sq. mile			41.7	45.1	48.6
Increase in 10 years, per cent.			.....	8.1	7.7

The total population, and especially the urban population, is small in comparison with that upon many water-sheds used with filtration for public water supplies. The sewage pollution of the water, therefore, is not great in total amount, but the conditions seem to have been favorable for the transmission of infection; for the typhoid rate in Washington has been high, and at times, at least, has followed the prevalence of the disease in the towns upon the water-shed.

The Potomac water is rather muddy. The amount of sediment carried by it, on an average, is many times greater than that carried by the rivers of New England and of the sandy glaciated regions of the Northern United States. On the other hand, the suspended matters are much less in amount than in most Southern streams. Probably, on an average, they do not amount to more than one-fourth of the quantities carried by the Ohio River at Louisville, or to more than one-twelfth of those carried by the Missouri at its mouth above St. Louis.

The amount of suspended matter carried by the water fluctuates widely. There are periods, sometimes lasting for months, when the Potomac water is comparatively clear. At other times the water is excessively turbid, and at times very turbid water flows continuously in the river for a week or more. At these times the water may approach the condition of the Ohio and Missouri waters, although the duration of the turbid periods is less.

The muddiness of the Potomac water and its pollution by sewage, and consequently its disease-producing qualities, have alike contributed to its bad reputation and to a desire for an improved water supply.

INVESTIGATIONS, DESIGN OF PLANT, ETC.—Mechanical filtration for the Potomac water was proposed in 1894 by the late Col. George H. Elliott. In 1899 an appropriation, subsequently increased to $8,000, was made for an investigation of purification processes. This investigation was made under the direction of the late Lieut.-Col. A. M. Miller, then in charge of the Washington Aqueduct, assisted by Mr. R. S. Weston, Assoc. M. Am. Soc. C. E. At the same time Mr. Hardy made preliminary investigations for a filter plant. As a result of the studies it was concluded that sand filters would not be successful at Washington unless a coagulant was used for preliminary treatment, and that mechanical filters would be preferable.* Objections raised by the Medical Society of the District of Columbia thwarted the proposal to use coagulant in any connection, and slow sand filters were finally authorized by Congress. During the investigations caused by the objections to a coagulant, Messrs. Rudolph Hering, George W. Fuller and Allen Hazen, M's Am. Soc. C. E., reported on this and related subjects, advising that sand filters should be used with preliminary chemical treatment when sedimentation alone was insufficient, which it was estimated would be on an average of about 30 days per year.*

The site finally chosen for the purification works adjoined the Washington City Reservoir and was near the Soldiers' Home grounds. During the preparation of plans and construction of the works the successive engineers in charge of the Washington Aqueduct, and therefore of the filtration plant, were Colonel Miller, Capt. W. P. Wooten, Col. Smith S. Leach, Lieut.-Col. R. L. Hoxie, and Capt. Spencer Cosby, M. Am. Soc. C. E., who has been in charge since December, 1905. Various army officers have been in direct charge of the filters under the successive engineers in charge of the Washington Aqueduct, Lieut. E. J. Dent having occupied this position since May 10, 1905. Mr. Hardy, as already stated, has been connected with the work from the start, and Mr. Hazen practically so. Contracts for construction were awarded early in 1903, and the first filter was put in operation Aug. 18, 1905. One additional filter was started

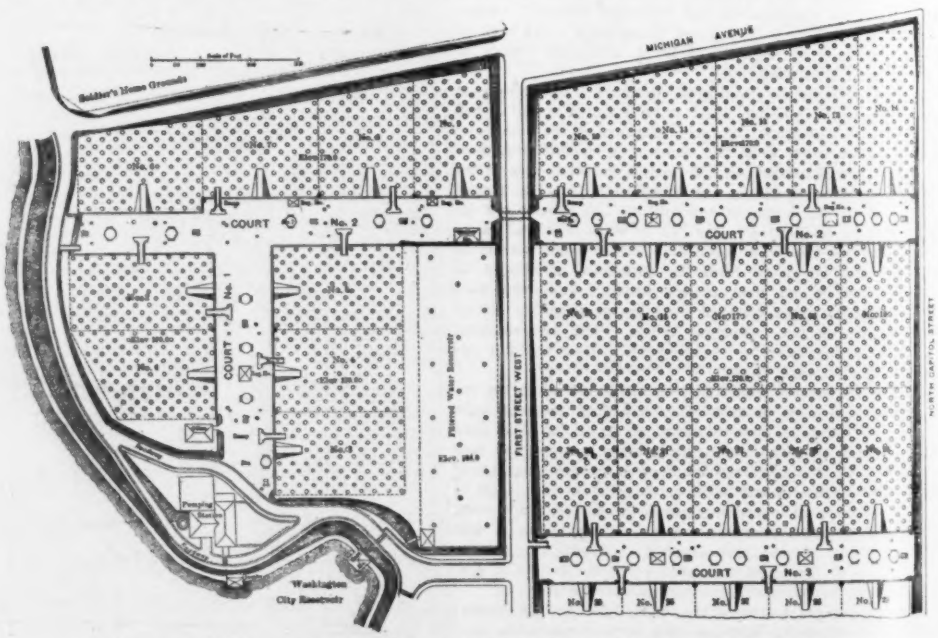


FIG. 1. GENERAL PLAN OF WATER PURIFICATION WORKS, WASHINGTON, D. C.

*[See Engineering News, May 17, 1900, for a lengthy abstract of the first-named report, and Feb. 28, 1901, for the second report in full.—Ed.]

each second day thereafter until Oct. 5, 1905, when the entire city was supplied with filtered water.

GENERAL PLAN.—The general plan of the filters and accessories is shown by Fig. 1. Water is pumped from the Washington City Reservoir to the filters under lifts ranging from some 20 to 30 ft. or more, and flows from the filters through regulator houses to a 14,000,000-gal. pure water reservoir with a flow line 18 ft. above the adjoining reservoir. Wherever masonry was employed concrete was used in the construction, "the general design following closely the lines of the Albany filters."* Sections showing the concrete construction are given in Fig. 2. The variations in the outer walls are due to variations in the thickness of the embankments supporting them. Considerable space is given in the paper to an account of settlements in the masonry structures due to filled ground antedating the construction of the filters. The authors state that the settlements do not "in any way affect the stability or usefulness of the plant."

FILTER UNDERDRAINS.—In designing the drainage system (Fig. 3) the same general principles were followed as in the case of the Albany filters. The central drain, however, was provided with "compensating orifices, to balance the frictional resistances and velocity heads in the main drains," in order to prevent differences in the rate of operation at points near to and remote from the drains, particularly just after cleaning, when the resistance of the sand is very small. Regarding the compensating orifice, the authors state:

> The principle of the compensating orifice is to introduce resistances, at each point where laterals enter the main drain, equal to the combined frictional resistance and velocity head in the main drain from the most remote point to the point in question. If the computations are correctly made, this would result in making the resistance from any point back of a compensating orifice, through it, and thence to the outlet, precisely the same as from any and all other similar points. The result should be to draw water at exactly the same rate of filtration from each section of the filter. As all the losses in the underdrains and compensating orifices change with the changes in rate in nearly the same ratio, namely, as the square of the rate of filtration, it follows that a compensation adjusted for one rate of filtration is substantially right for any other rate. The fact that the loss of head in the sand varies directly as the rate, instead of as the square of the rate, does not enter into the comparison; for, at a given rate, this loss is the same for all parts of a filter, and therefore there is no tendency from it to produce unequal rates of filtration.
>
> The compensating orifices were brass disks, with circular openings cut to the computed diameters and placed in the entrances to the main drains, all other parts of which were finished water-tight, or substantially so.†

By this construction the main drains were 24-in. tile pipe throughout, which is sufficient; but without the orifices it would have been necessary to use 36-in. pipe. The saving effected by the use of the orifices was roughly $500 per acre, or $14,500 for the plant.

GRAVEL AND SAND.—The gravel placed at the bottom of the filters ranged in depth from 12 ins. midway between the piers to 3 ins. at the piers, and was composed of crushed trap or granite. No gravel was placed within 2 ft. of the outside walls.

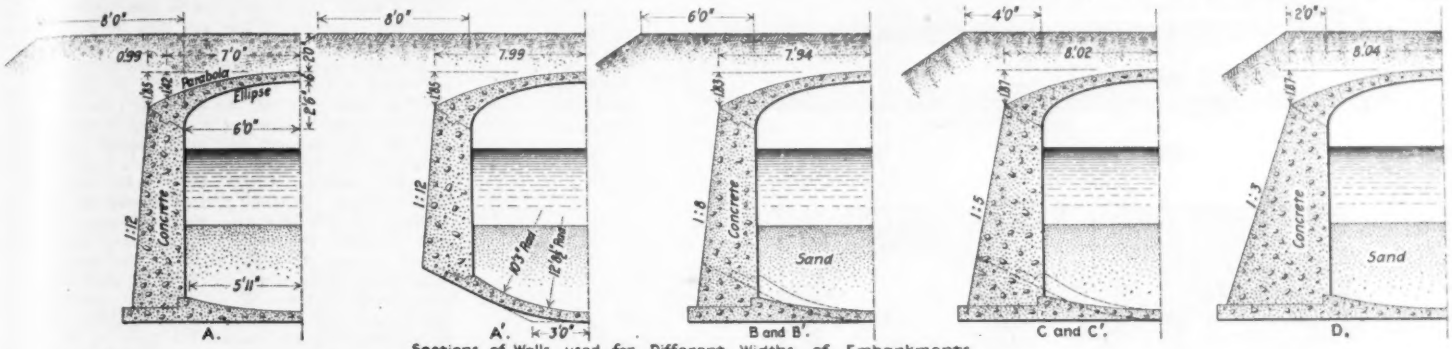


FIG. 2. CROSS-SECTIONS SHOWING DESIGN OF CONCRETE FOR WATER FILTERS, WASHINGTON, D. C.

After settlement the average depth of the filter sand was 38 ins.; the sand settled, on the average, about 5% of the original depth. The specifications for sand were sufficiently general to admit sand from a variety of sources. The sand actually used was taken from a bank consisting of layers of clay and sand located at Laurel, Md., half-way between Washington and Baltimore on the main line of the Baltimore & Ohio R. R. The clay was in layers ranging in depth from a few inches to several feet in depth, and it was impossible to take the sand without the clay. The sand and clay were therefore excavated together by means of steam shovels, loaded on cars, and hauled over temporary tracks to a screening and washing plant on the main line of the railroad. The mixed material was dumped from the cars through a coarse grating which took out many of the larger lumps of clay. A revolving screen, with holes about 2 ins. in diameter, removed more of the clay lumps, after which a link-belt elevator took the material to a revolving screen on which played water jets. These jets and screens removed additional clay and some fine gravel, and excluded all particles more than 5 mm. in diameter, in accordance with the requirements of the specifications. All the remaining material then passed to a series of pug-mills, which broke up the clay lumps and, by means of the excess of water wasted over their tops, removed some of the clay. Finally, the sand with such clay as remained passed through sand washers in the form of boxes 24 ins. wide, 16 ft. long, and 18 ins. deep at the upper end, the bottoms sloping 1 in 6 to the point of discharge. In the bottom of these boxes were four pipes perforated the entire length with holes opening downwards, through which water was forced at a rate of about 1 cu. ft. per min. per sq. ft. of box area. The sand being admitted at the upper end and the water being admitted from below and discharging from the top, the sand was kept "in a semi-suspended state and practically in the condition of quicksand." There was, however, a forward motion of the sand toward the lower end of the box, and at the same time the larger and heavier particles of sand were carried downwards and the finer particles were carried upwards and discharged with the waste water. The wasting of the finer particles was effected in part by controlling the quantities of sand admitted to the box, the sand level usually being kept at about 6 ins. below the water surface. The [quasi] quicksand, in the ratio of about 9 parts of sand and 1 of water, was dropped from the lower end of the washer into a hopper which, being controlled by a gate, was used for loading cars. About 1 cu. yd. of sand per hour per sq. ft. of box area was washed, and sometimes more. A box of this general character was used at Yonkers, N. Y. (Eng. News, July 14, 1904), and also at Providence, R. I. On arriving at the filter plant the sand cars were unloaded from an elevated siding into hoppers provided with sand gates, under which carts were driven for loading. The carts in turn were taken to the manholes in the filter roof and the sand was dropped through the manholes ohto chutes which by being revolved distributed most of the sand into place without further handling. This method is being used for replacing washed sand in the filters.

The specifications provided that the sand should be entirely free from clay, but when they were drawn it was expected that sand would be dredged from the Potomac River. It was found impossible to test the amount of clay in the sand by ordinary mechanical analysis or sifting, so

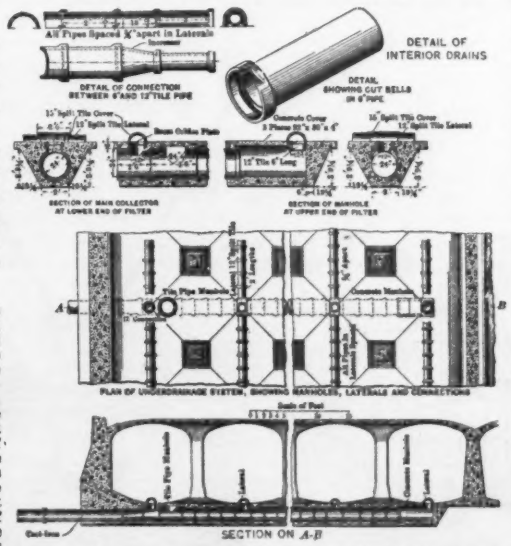

All Pipes Spaced 8' apart in Laterals
DETAIL OF CONNECTION BETWEEN 8' AND 12' TILE PIPE
DETAIL OF INTERIOR DRAINS
DETAIL, SHOWING CUT BELLS IN 8" PIPE
SECTION OF MAIN COLLECTOR AT LOWER END OF FILTER
SECTION OF MANHOLE AT UPPER END OF FILTER
PLAN OF UNDERDRAINAGE SYSTEM, SHOWING MANHOLES, LATERALS AND CONNECTIONS
SECTION ON A-B

Fig. 3. Underdrainage System, Slow Sand Filters, Washington, D. C.

*Trans. Am. Soc. C. E., Vol. XLIII., p. 244. [Also see Engineering News, Feb. 10 and Oct. 20, 1898.]

†[See Engineering News, Feb. 13, 1902, for compensating orifices designed by Mr. Hazen for use there, as proposed by the first plans made.—Ed.]

it was necessary to agitate a weighed quantity of sand for several minutes in several times its volume of water, then allow the water and sand to stand for one minute and measure the resulting turbidity by the platinum wire method, with Jackson's turbidimeter for use at night. The turbidity was multiplied by 40 (ratio of volume of mixture to weight of sand), thus giving the "turbidity in the sand in parts per million by weight." It was found that one part of clay by weight corresponded to some two parts of turbidity, owing to the fact that the clay particles were finer than the standard turbidity particles. A limit of 4,000 parts of turbidity per 1,000,000 "was rigidly insisted upon," but generally the turbidity yielded by the sand was less than 3,000 and frequently less than 2,000. The latter figure corresponded to "less than 0.1% of actual clay by weight in the sand as delivered."

PIPING AND VENTURI METERS.—The raw water is carried from the pumps to the filters by two lines of riveted steel pipe, one 72 ins. in diameter, supplying 19 filters, and one 54 ins., supplying 10 filters. The steel pipes are coated with asphalt and surrounded by concrete. The piping that conveys the filtered water to the pure water reservoir is of cast-iron, 48 ins. in diameter or less.

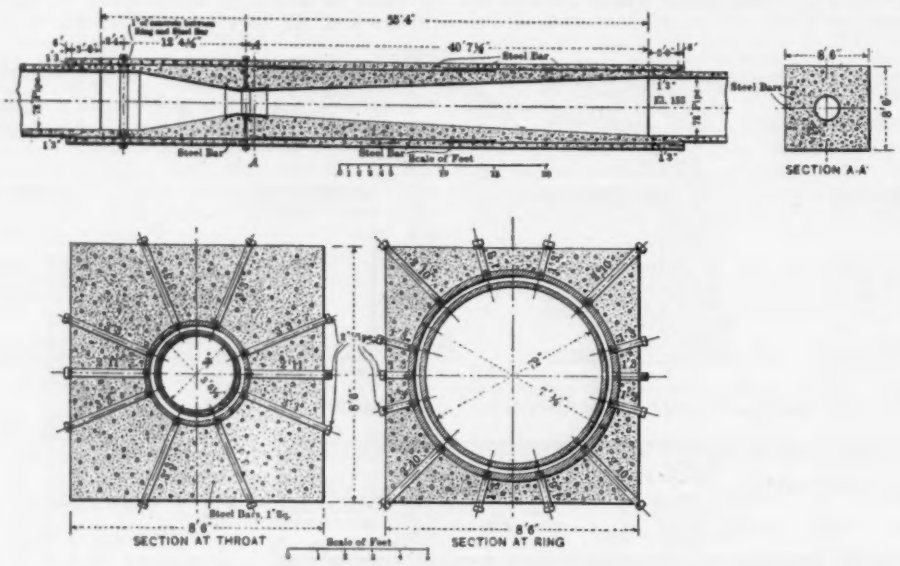


FIG. 4. 72-IN. REINFORCED CONCRETE VENTURI METER, WASHINGTON FILTER PLANT.

Fig. 4 shows the 72-in. Venturi meters, built of reinforced concrete and used for measuring the supply to the filters. The meters were built with the proportions described by Mr. Clemens Herschel* M. Am. Soc. C. E., the fittings and registering devices being supplied by the Builders' Iron Foundry.

REGULATION.—The system of regulation for the control of the filter effluent is described in the paper as follows:

> The regulation of the quantity of the effluent from each filter is secured by a gate with a large wheel and a graduated standard upon the filter outlet. The discharge is through a Venturi meter, with suitable apparatus placed directly behind the controlling gate to show the rate of filtration and loss of head. Watchmen observe and record these data at stated intervals, and change the outlet gate when necessary in order to maintain the desired conditions.
>
> This system of regulation was selected in preference to an entirely automatic system, as the required apparatus is much simpler, and no additional labor is involved. This is because watchmen must make the rounds of the filters in any event to see that all is going well, and it is never necessary to change the adjustments oftener than such rounds would be made.
>
> The pure-water reservoir is arranged so that when it becomes full it will back up water against the filters and reduce the rate of filtration automatically, but the outlets from the filters to the pure-water reservoir are placed at such an elevation that a considerable drop in the pure-water reservoir does not put a corresponding suction or pull upon the filters, but, instead, the loss of head is limited to about 4 ft. Any fall in the water in the pure-water reservoir below the level corresponding to this loss of head has no effect upon the rate of filtration.

SAND EJECTORS AND WASHERS.—In cleaning the filters the dirty sand is first shoveled into heaps, then thrown into portable ejectors and conveyed by water through hose and pipe to the sand washers in the courts (see Fig. 1), and from these washers the sand is ejected to cylindrical reinforced concrete storage bins with a capacity of about 250 cu. yds. each. The portable ejectors are shown by Fig. 5, the hoppers and ejectors for the sand washers by Fig. 6, and the general arrangement of ejectors, washers and storage bins by Fig. 7. Some valuable studies made in connection with the design of the sand ejectors are given in the report and, with descriptions of the sand handling apparatus, are quoted herewith, but with two diagrams omitted.

The movable ejectors have two novel points in their design. First, the water for bringing the sand into suspension is introduced gently at the bottom of the ejectors and slowly rises as the sand is shoveled into it. It was found by experiments made under the authority of Colonel Miller that sand could be more effectively loosened and suspended in this way than by playing water upon it from above at considerable velocity. The mixture thus produced contains more sand in proportion to the water, and the ejectors therefore throw more sand and less water. Second, the discharge ends of the ejectors beyond the throats are made with a very flat batter, like the discharge end of a Venturi meter. The batters for the discharge are 1 to 22, in place of 1 to 6, used at Lawrence, Albany, Philadelphia and in other earlier designs. A series of tests showed that with this modification, and with fixed water and sand quantities, twice as much pressure at the discharge could be obtained as with the usual batter on the discharge. In other words, with given quantities of sand and water, it is possible to force the sand through twice as long a line of discharge piping, by the use of the flatter batter in the discharge pipe beyond the throat of the ejector. The saving clearly comes from the utilization of the velocity head in the throat, which was largely lost with the greater batter on the discharge.

Water to operate the movable ejectors and all other parts of the sand-washing and handling system is provided under from 80 to 100 lb. pressure by pumps and pipes installed for that purpose. Unfiltered water from the main pump well is used. The pipes take the water to each court and 5-in. wrought-iron pipe lines take it down each side of the filters. These have hose connections at intervals averaging about 60 ft. Hose, 2½-in. in diameter, and seldom more than 100 ft. long, completes the feed line. The discharge of mixed sand and water is first through a line of 3-in. hose, seldom more than 100 ft. long, to the nearest side of the filter. Here connection is made with a 4-in. wrought-iron discharge line leading to one of the stationary washers in the courts. The feed and discharge pipes always go together, making a pair, with corresponding connections, and with connections under the vaulting but above the top of the filter walls, so that each pair is capable of serving two filters. The pipes are also laid to grades, with blow-offs, so that when they are not in use they can be entirely drained to prevent freezing.

The design of the pipes for carrying the mixed sand and water was given considerable attention. If they were too small, the capacity would be limited; the workmen would have to wait for the ejectors to carry off the sand that had been shoveled into them, and the apparatus would not prove economical. On the other hand, if the pipes were too large for the minimum use, the sand would settle out of the water, form a deposit in the pipes, and stop the operation.

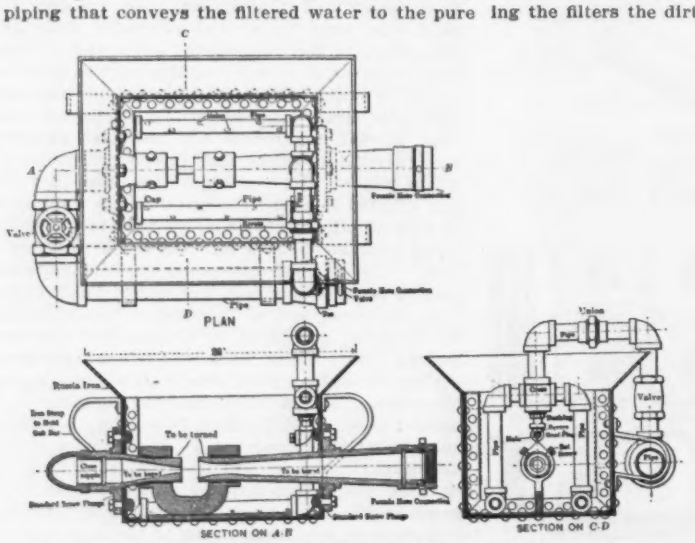


FIG. 5. DETAILS OF PORTABLE SAND EJECTOR, WASHINGTON FILTER PLANT.

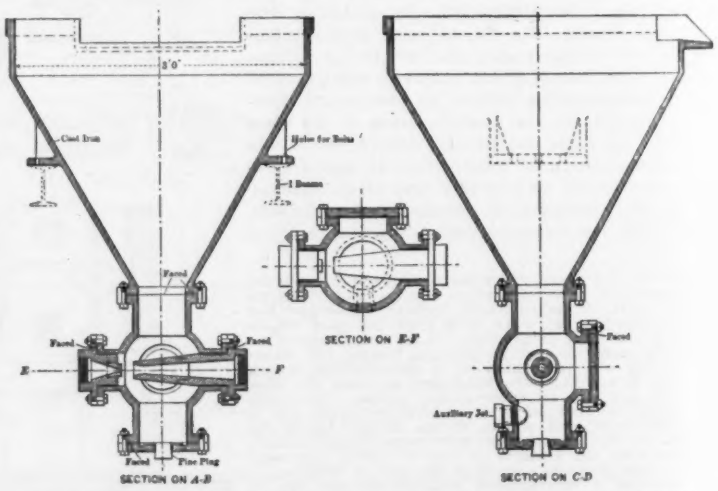


FIG. 6. DETAIL OF HOPPERS FOR SAND WASHERS, WASHINGTON FILTER PLANT.

By authority of Colonel Miller, tests were made to determine the power and capacity of ejectors of different sizes and types, the frictional resistances of mixtures of sand and water in pipes, and the minimum velocities at which such pipes could be regularly operated without stoppage by separated sand.

In making these tests an ejector was connected by hose to a length of wrought-iron pipe, which finally discharged into a tank on a wooden trestle. The outlet from

*Trans. Am. Soc. C. E., Vol. XVII., p. 228.

this tank was through a circular hole in a disk of sheet iron upon the bottom, which acted as a standard orifice. Pressure gages connected with the pipe at intervals gave better results as to loss of head than could be secured by differential gages of glass tubes. There is a throbbing in pressure, particularly at moderately low velocities, perhaps due to a partial deposition and subsequent picking up of sand particles, and to separations into more and less dense mixtures, which made it difficult to get satisfactory readings in the glass tubes. The pressure gages were less sensitive and therefore much more easily read, and on the whole sufficiently accurate.

The time required to throw a measured volume of sand was observed by one man, while others read the gages on the discharge pipe at 10-second intervals. At the same time the head over the standard orifices was noted, and from this the total volume of flow was computed.

Occasionally the discharge from the orifice was taken by a chute to a tank for a determined interval. The results thus secured were used to compute the coefficient of discharge of the orifice (which was 0.63 for sand mixtures, in place of 0.60 for water, probably because the sand formed a flat cone about the orifice). The sand contained in this water was also often separated and measured as a check on the rate at which it was passing.

Such experiments were made with 3-in. and 4-in. pipe, from which diagrams of friction were prepared for use in designing the piping for the filters. They are not as accurate as could be wished, and further data of this kind are to be desired.

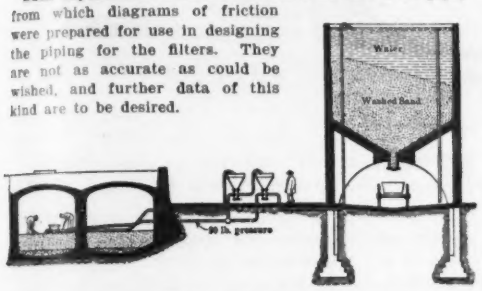


Fig. 7. Arrangement of Sand Ejectors, Washers and Storage Bins, Washington Filter Plant.

With an average velocity as low as 2 ft. per sec., a pipe would promptly fill up with sand and shut itself off. This was true, whatever proportion of sand was present in the water. At 2½ ft. per sec. flows of sand and water were sometimes maintained, but always with great fluctuations in friction, which, the writers think, indicates a partial deposition of coarse particles and an occasional picking up and carrying forward of an accumulation. Occasionally, at this velocity, the pipe would fill so as to shut off the flow.

At velocities of 3 ft. per sec. the flow was much steadier, and stoppages almost ceased. At 4 ft. per sec. and upward mixtures of sand and water acted quite as a fluid, and the flow was almost as steady and regular as that of so much water, although the frictional resistance was much greater.

As a result of these studies and calculations based upon them, it was concluded that:

A short length of 3-in. hose or pipe would not throttle an ejector too closely, but a line of such pipe long enough to serve the most distant positions of the movable ejectors would cut down the rate of discharge to such an extent that the men would have to do too much waiting for the ejectors.

It would never be possible to discharge two ejectors through the same 3-in. pipe.

Adequate carrying capacity is furnished by 4-in. pipe, and one such pipe will usually be capable of taking the discharge from two ejectors, if occasion demands.

To prevent obstruction in 4-in. pipe, the jet of the ejector should be of such size as to throw water enough to produce a velocity of 3 ft. per sec. in 4-in. pipe. In practical operation the sand taken up and the water introduced through the irrigator will increase the volume by one-third, and will produce a velocity of 4 ft. per sec. in the 4-in. discharge, and this is desirable.

With two ejectors discharging through one 4-in. pipe, the velocity in it will be about 8 ft. per sec., which is permissible.

The most advantageous ratio of diameter of jet to throat in ejectors was studied at some length, and sufficient information secured to select a throat diameter of approximately the most advantageous size. A diagram of some of these results was made, which shows the results clearly.

A large throat will throw more sand, but the pressure that can be produced to overcome friction in the piping decreases almost as the square of the throat diameter. The ratio of jet to throat, as computed for the different ejectors, based on the data of the experiments, varied greatly. For instance, in the movable ejector the jet is 0.59 of the throat. In the first ejector in the stationary washers, which only throws the sand from one hopper to the next, the ratio is 0.34, and in the second one, which lifts the sand to the sand-bin, the computed economical ratio is 0.48. In all cases the ratios are changed by wear, and the throats will need to be replaced frequently.

The stationary sand washers in the courts are like those designed by one of the authors of the paper [Mr. Hazen] for use elsewhere [in the Pittsburg filtration plant as originally designed; see. Eng. News Feb. 13, 1902; our Fig. 6 shows only a portion of the washers, illustrated in more detail in the article just mentioned.—Ed.]. The space permitted a batter of only 1 in 14 in these Washington ejectors, but "this produces an ejector powerful enough to lift the sand about 26 ft."

The material thrown to the storage bins consists of 1 part of sand to 3 or 4 parts of water. The bin is provided with an overflow at mid-depth and at the top, through which the surplus water is discharged in succession. There is one bin for each filter, but the bins are so connected that each filter can be served by a number of bins.

The sand handling and washing machinery was for the most part ready for use the last part of April, 1906. The average costs for labor between that date and the date of the preparation of the paper [not stated] was 39 cts. per cu. yd., divided as follows: Scraping, 5 cts.; ejecting, 16; washing, 5; storing and replacing, 13 cts. It is thought that further experience will show that the cost of removing, washing and replacing the sand does not at the most exceed 40 cts. per cu. yd. Corresponding figures at some of the older filter plants are as follows: Lawrence, Mass., in service 1893, $1.70; Mount Vernon, N. Y., 1894, $1.51; Albany, N. Y., 1899, $1.38. The average depth of sand removed at Washington is greater than at other places, but as the scrapings are less frequent the quantity of sand handled per million gallons of water filtered is considered to be of an average figure.

PUMPING PLANT, ETC.—Three 40,000,000-gal. Worthington centrifugal pumps, direct-connected to Harrisburg engines, with a guaranteed duty of 100,000,000 ft.-lbs. per 1,000 lbs. dry steam and a duty on tests of 97,500,000 ft.-lbs., are used to lift the water from the reservoir to the filters. The normal minimum lift is 21 ft. and the possible maximum lift is 35 ft. Two 2,500,000-gal. pumps, working under 100-lb. pressure, are provided for supplying the sand washers. It is expected that one pump, working one 8-hour shift per day, will as a rule be sufficient. These pumps showed a duty test of 65,000,000 ft.-lbs. An electric lighting plant is provided to serve all the buildings, and although it is expected that the light for the filters will generally be secured through the manholes, one 16 c. p. light is provided for each 14-sq. ft. section of filters.

LABORATORY.—A completely equipped laboratory and office building, 36 × 50 ft., with a high, light basement, is located near the pumping station. From its windows a good general view of the plant can be had.

COST OF PLANT.—The appropriation for the plant was $3,468,405, and the final cost will not differ greatly from this. The approximate cost in detail is shown by Table II.

Based on net area, the Washington filters cost about 65% more than the Albany filters, due chiefly to higher unit prices and also to "the supposed difficulty of securing filter sand at Washington, a difficulty which proved to be unfounded."

RESULTS OF OPERATION.—As already stated, the filter plant was put into gradual operation, beginning with one filter on Aug. 18, 1905, and including all the filters on Oct. 5, 1905. The laboratory building was not completed when the first filter was put in service, but bacterial counts were begun early in September. The effect of the filters on turbidity was noticed immediately. It was necessary to clean some of the filters during October, before the sand handling plant was in shape. Other irregularities in the service in the early history of the plant were caused by the fact that the pumps were still in the hands of the contractors. Data of operation for the nine months from October, 1905, to June, 1906, are given in Tables III. to VI.

The water reaching the Washington filters is settled to a far greater extent prior thereto than is the case with any other filters of this type in America. All the sand and silt are thus removed, so that the only turbidity remaining is clay in a very finely divided state. The sediment layer usually formed on the surface of the filters is "often or usually" not formed here, but instead the clay particles "gradually fill up the pores in the upper part of the sand layer to a depth of 2 or 3 ins.," while others "are deposited in the lower part of the sand layer," and "still others" appear in the effluent. The authors further state:

This condition results in an abnormally long period between scrapings, and in soiling the sand to a most

Table II.—Approximate Cost of Washington Filtration Plant.

Pumping Station:	
Intake, with gates and building	$11,500
Venturi meters, 72-in. and 54-in. (reinforced concrete)	5,000
Electric lighting, engines, etc.	7,000
Four 200-HP. boilers, in place	14,800
Four Roney stokers	4,100
Two Green economizers, in place	5,100
Three 36-in. centrifugal pumps, with engines	42,000
Two sand-washer pumps	8,100
Piping, valves, etc.	13,100
Coal, oil, and running tests	3,500
Traveling crane	1,600
Chimney, with foundation	5,800
Coal vault	11,000
Building, with foundation and suction well	51,000
Total cost of pumping station	$183,600
Twenty-nine Filters:	
Excavating, 862,700 cu. yds., at 30 cts.	$258,800
Filling, 299,500 cu. yds., at 30 cts.	89,900
Sodding slopes, and seeding	7,300
Roads and drains outside of filters	16,200
Concrete tunnel under First St.	3,100
Concrete (including cement):	
Floors 36,563 cu. yds., at $6.75	246,800
Walls, 19,038 " at 7.35	139,900
Piers, 6,964 " at 8.25	57,500
Vaulting, 34,920 " at 8.75	305,500
Ramps leading to tops of filters	6,800
Court paving, including cement	42,000
Central underdrains, 7,900 lin. ft., at $1.65	13,000
Interior drainage system, 29 filters, at $500	14,500
Drainage of roofs, 29 filters, at $266	7,700
Materials placed in masonry, 29 filters, at $200	5,800
Doors and beams at entrances	3,700
Filter sand, 157,725 cu. yds., at $2.65	418,000
Filter gravel, 36,500 cu. yds., at $2.75	100,400
Cast-iron piping and special castings	117,000
Steel rising main, including concrete backing	76,800
Pressure pipe system	2,000
Sand-washer pipe system, complete	24,000
Sand-washing apparatus, 19 washers, 8 ejectors, and hose connections, complete	4,800
Elevated sand bins, 29, capacity 250 cu. yds. each	60,800
Exterior drainage system	25,300
Venturi meters and indicating apparatus	11,400
Sluice gates and gate valves	19,900
Regulator houses, including substructures	27,300
Office and laboratory, with equipment	19,700
Shelter house for workmen	4,800
Water and gas lines to buildings	11,200
Electric lighting, courts and filters	41,900
Cleaning up and miscellaneous	11,600
Total cost of 29 filters	$2,197,000
Filtered Water Reservoir:	
Excavation, 83,500 cu. yds., at 30 cts.	$25,100
Filling, 18,000 " at 30 cts.	5,400
Concrete (including cement), 15,290 cu. yds. (average), $7.60	116,000
Gate houses for filtered water reservoir (superstructure)	3,500
Total, filtered water reservoir	$150,000
Lower Gate House:	
Pipe lines to lower gate house	$6,000
Lower gate house	18,300
Total	$24,300
Land	$619,900
Clerical and Engineering Work:	
General plans	$36,000
Surveying	32,000
Field office force	21,000
Main office force	20,000
Inspecting work and testing materials	67,000
Watchmen	4,500
Temporary office	1,000
Total, clerical and engineering	$181,500

SUMMARY.

Pumping station, including intake, Venturi meters, electric light generating apparatus, concrete and stack, complete	$183,600
Twenty-nine filters, with excavation, grading, concrete work, piping, regulator houses, shelter house, laboratory and office, electric light wiring, sand-washing apparatus, sand bins, etc., complete	2,197,000
Filtered water reservoir, including excavation, concrete work, gate house, regulating apparatus, etc., complete	150,000
Lower gate house and pipe line	24,300
Land	619,900
Engineering and clerical work	181,500
Total cost of work	$3,356,300
Total amount appropriated	$3,468,400
Balance available for operation and contingencies	112,100
Total cost for construction, excluding land	2,736,400
Percentage for engineering and supervision	6.65
Cost per acre for constructing 29 filters: $2,197,000 ÷ 29 =	$75,700
Cost per million gallons capacity of filtered water reservoir: $150,000 ÷ 14.2 = $10,600.	

Table III.—Turbidity of Potomac River, Settled and Filtered Water, Washington, D. C.; Averages by Months.

Month.	Great Falls.	Reservoirs. Dalecarlia.	Reservoirs. George-town.	Reservoirs. Washington City.	Filtered water.
1905.					
Oct.	36	21	18	11	1
Nov.	19	19	14	11	1
Dec.	199	84	74	39	6
1906.					
Jan.	94	60	60	52	12
Feb.	45	41	29	22	3
Mar.	272	181	56	46	6
April	167	72	58	46	7
May	56	20	16	10	2
June	303	125	94	41	2

This operation was without coagulant, and the turbidity of the effluent clearly shows the need of it.

Table IV.—Bacteria in Reservoir and Filtered Water, Washington, D. C.; Averages by Months.

Month.	Reservoirs. Dalecarlia.	Reservoirs. George-town.	Reservoirs. Washing-ton City.	Filtered water.
1905.				
Oct.	.....	.....	198	78
Nov.	.....	.....	153	27
Dec.	15,637	17,884	3,750	60
1906.				
Jan.	.....	15,719	1,520	39
Feb.	4,086	1,823	592	16
Mar.	1,105	883	654	19
April	1,658	715	399	22
May	206	94	66	17
June	4,628	334	224	17

Table V.—Operation of Pumping Plant at Filters, Washington, D. C.

	Ave. million gals. pumped to filters.	Ave. lift, ft.	Ave. sand wash-water pumped, 100 lbs. pressure.	Coal burned, lbs.	Duty per 100 lbs. coal.
1905.					
Oct.	67.9	23.3	...	19,382	68.9
Nov.	66.1	21.6	...	17,198	69.4
Dec.	67.2	21.5	...	19,899	60.4
1906.					
Jan.	65.27	21.6	...	20,659	57.2
Feb.	68.69	21.2	...	20,264	61.1
Mar.	64.28	20.1	...	18,494	61.2
April	62.7	21.5	...	19,212	60.9
May	65.63	21.1	0.6	20,334	62.7
June	67.12	22.8	0.9	23,288	63.9

Table VI.—Filter Cleaning Data, Washington Filters.

Month.	Number filters cleaned.	Runs. Ave. days.	Runs. Million gals. per run.	Total average cost per million gallons. Cleaning.	Pumping.	Office and lab.	Ave. total.
1905.							
Oct.	13	49	146	$0.63	$0.90	$0.43	$1.96
Nov.	12	45	136	0.58	0.94	0.53	2.05
Dec.	5.25	51	172	0.40	0.98	0.54	1.92
1906.							
Jan.	4	69	233	0.36	1.38	0.74	2.48
Feb.	2⅜	104	332	0.33	1.14	0.59	2.06
Mar.	4⅜	130	552	0 51	1.16	0.61	2.28
April ...	7	149	366	0.76	1.34	0.74	2.84
May	8½	130	298	0.79	1.01	0 59	2.39
June ...	11	125	297	1.05	1.54	0.59	3.18

unusual depth. These conditions were fully indicated in the experiments made by Mr. Hardy and Mr. R. S. Weston, under the direction of the late Colonel Miller, and experience in the practical operation of the plant has fully demonstrated the correctness of these experimental results and of the deductions made from them at the time.

The use of coagulant would change this and make the conditions more nearly normal, because the suspended matter in the applied water would be reduced in amount and changed in character, being in the form of a loose floc, capable of being stopped at the surface layer, and thus forming a normal sediment layer.

The cost of the plant complete, it is stated, will be less than $3,400,000, which at 5% interest and depreciation would result in a capital charge of $170,000 per year, or $7 per 1,000,000 gals. for an average of 67,000,000 gals. filtered per day thus bringing the operating expenses, total cost of filtration, to about $9 per 1,000,000 gals. The authors state that since the Government pays an unusually low rate of interest, the actual cost is even less.

NECESSITY FOR PRELIMINARY TREATMENT.—The authors believe that the filters as built should produce "water entirely satisfactory from a hygienic standpoint," but believe "that they will not always be able to produce a water free from turbidity." For probably not more than $5,000 the necessary works for adding a coagulant to the water between the Dalecarlia and Georgetown Reservoirs could be provided. The cost of operating the proposed coagulation plant would be about 50 cts. per 1,000,000 gals. [operated only a small part of the year], but the clarification effected would reduce the cost of cleaning the filters. Besides the $5,000 mentioned, it would be necessary, in order to operate a coagulating plant properly, to concrete the bottom of the Georgetown Reservoir and to provide the reservoir with baffles, which would cost altogether about $100,000.

The condition of the water could be greatly improved and the cost of operating the filters lessened, even though a coagulating plant were not provided, if the consumption were to be reduced from the present 200 gals. per capita per day to a reasonable quantity, say a total of 50,000,000 gals. per day. At the low total rate thus mentioned, it would not be necessary to draw water from the river when its turbidity is at the highest.

As will be seen from the figures previously given the consumption already nearly equals the capacity of the aqueduct and the filter plant, alike. By building a pumping station at the Dalecarlia Reservoir and lifting the water 5 or 6 ft., the capacity of the aqueduct could be increased to about 100,000,000 gals. per day, and if the turbidity of the water were lowered by coagulation the filter plant could be operated at the rate of 4,000,000 gals. per acre per day, which would give a total working capacity of 100,000,000 gals. per day.

A NEW THERMO-ELECTRIC RECORDING PYROMETER.

The thermo-electric pyrometer here illustrated and described differs from that previously taken up in our columns* in that the present instrument is of the recording type.

The recorder arm moves freely in front of a chart which is revolved by clockwork once in 24 hrs., or at any other desired rate. The charts are prepared with a semi-transparent smoked surface which is so sensitive that a record may be made upon it with a hair. The chart when applied to the instrument is supported over only a portion of its surface, by the semi-circular plate shown in the lower portion of Fig. 1.

The clockwork for revolving the chart is contained in the round case behind the semi-circular chart support, and is provided with an auxiliary attachment for periodically vibrating the unsupported portion of the chart, thus bringing its

Fig. 2. The Smoked Chart Used in the Recording Pyrometer, Fig. 1. The Curve Shows the Temperatures Recorded in a Lead Bath.

smoked surface at intervals of a few seconds into contact with the pointed end of the recorder arm. The series of marks made by the periodic contact of the recorder arm where the carbon is removed from the chart, forms a continuous curve unless the changes of temperatures are extremely rapid.

*Engineering News, Feb. 8, 1906; p. 159.

After the record of the day is complete the chart is removed from the instrument and "fixed" by immersion in a solution consisting of gasoline or alcohol to which has been added a small amount of concentrated fixative. After drying,

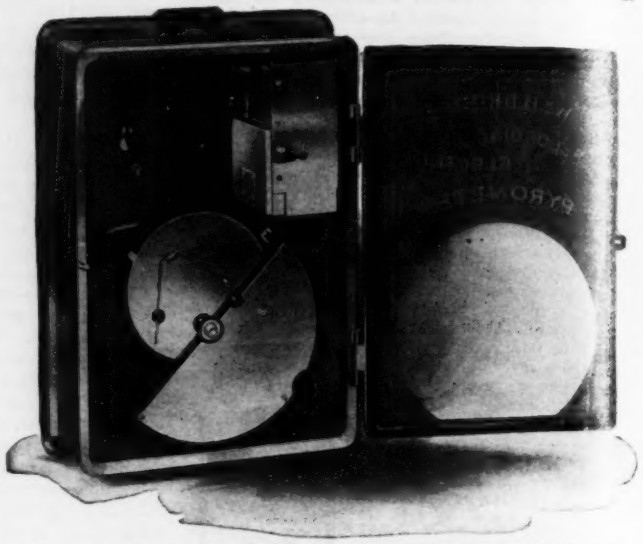


FIG. 1. A NEW THERMO-ELECTRIC RECORDING PYROMETER, OPENED TO SHOW THE WORKING PARTS.

the charts may be handled and filed away without danger of destroying the record.

Fig. 2 is a reduced photographic reproduction of a smoked chart with a record of the temperature in a lead bath which is used for calibrating these pyrometers. It is interesting to note the constancy of the temperature during the period of nearly half an hour while the mass of metal was cooling and passing from the molten to the solid state.

The protecting case containing the galvanometer is hinged to the back of the recorder and in Fig. 1 is shown turned to one side. This arrangement provides against danger of injury to the recorder arm while charts are being changed and the clock wound.

The special features of the charts are that the coating of lamp black on them is not sufficient to obscure the graduations, and the edges and center are unsmoked. The charts can therefore be conveniently handled and packed for shipment.

The couples employed for ranges not exceeding 2,000° F. are made of special alloys which are inexpensive and may be of almost any desired form or length to suit the special requirements. For ranges above 2,000° F. the standard Le Chatelier platinum and platinum rhodium elements are employed.

Compound couples are used to reduce the cost. The inexpensive alloys employed for the extension of the couple are such that the two secondary thermo-electric effects at the junctions with the platinum and platinum rhodium elements neutralize each other if the temperature at these junctions does not exceed 1,200° F. The indications on the instrument will be the same as if the whole couple had been made of the precious metals.

Where there are varying temperatures at the cold end of the couple, the mercury compensator is used; this automatically changes the resistance of the circuit so that no correction is necessary for the working range of the recorder.

This electric pyrometer is being placed on the market by Wm. H. Bristol, 45 Vesey St., New York.

AN ELECTRIC LAUNCH FOR TOWING BARGES and for inspection and transportation of workmen, has replaced a petroleum-driven launch used for this purpose on Lake Vyrnwy. The new launch will seat 25 persons, is 31 ft. long, and has a beam of 6 ft. 8 ins., with a draft of 2 ft. 3 ins. A 6-HP., 150-volt motor located amidships drives the propeller. The controller and steering wheel are placed forward, and an ammeter and a voltmeter are provided. A storage battery of 88 cells is carried under the seats, and on one charge will run the launch about 45 miles.

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The serious disaster on the Pennsylvania R. R. at a drawbridge near Atlantic City on Oct. 21 has been under investigation by a coroner's jury during the past week and the causes which brought it about have been determined with almost absolute certainty. As stated in this column last week, the derailment was caused at the entrance to the drawspan by the outer rail being out of place and elevated above its proper position so that the wheel flanges struck the outer side of the rail head and foot and dropped off the rail onto the ties at that point.

The thing that seems exceedingly strange to an engineer is that the rail could be thus out of place and yet the signals for the passage of trains over the draw show clear. Surely with a properly arranged drawbridge signal equipment the signals should be so interlocked with the drawbridge mechanism that a clear signal could not be given until the bridge is closed and locked and the track rails all properly alined for the passage of trains.

An investigation of the bridge itself, however, made by a member of the editorial staff of this journal, has discovered the weak link in the chain. We find that in order to turn the drawspan the track rails were lifted out of the guides on the abutments in which they rested and that the lifting mechanism was properly interlocked with the signals. The rails themselves, however, *were not secured to the lifting mechanism.* When that dropped, the rails dropped with it by their own gravity, provided they did not catch on anything and be thus held from dropping into place. If they did thus catch, however, there was no connection whatever between the rails in such a displaced position and the signal mechanism, and nothing to hinder the display of a clear signal even though all or any of the four rails at the ends of the drawspan might be so out of place as to make derailment of a passing wheel certain.

To bolster up this weak link, the railroad company made it the duty of the bridge tenders to inspect the rails at each end of the draw after closing and make sure that the rails were down in proper position before the bridge tenders gave a clear signal to the towerman. The clear signal was given by removing the red flag which the bridge tender stuck at each end of the draw when the bridge was opened. The aged bridge tender, Daniel Stewart, a man 65 years old, testified at the coroner's inquest that he inspected the rails, and found them all right after he closed the draw, just before the ill-fated train came along. He also testified, however, that several times last summer the rails caught when the bridge closed and would not drop into place until they were driven down with a sledge hammer. The conclusion, in the light of all the facts, must be that the bridge tender was mistaken, and that while he undoubtedly *thought* he saw all the rails down in place before giving the clear signal, as a matter of fact one rail caught, probably on the side of the guide on the bridge abutment, as it had apparently caught at times before, and in a position to derail the train when it came along.

It is the old, old story over again of the erring human mind vs. the operation of mechanism. Stewart made a mistake and three carloads of passengers were sent to the bottom of the river channel; but a vastly more important mistake was made when the link was left out of the interlocking mechanism, so that it became possible to clear the semaphore before the rails were down in position.

It is a surprising thing that such an omission in drawbridge signal installation should be found on the Pennsylvania R. R. lines, where modern signaling practice in the United States may be said to have originated and where, if anywhere in the United States, the best practice in signal engineering is expected.

We discuss at greater length on the next page that other mistake of leaving the bridge floor without the inside guard rails, which, had they been in place, would almost certainly have guided the derailed wheels across the bridge and onto solid ground on the opposite bank. As bearing on this matter, it is of interest to note that from the marks on the ties and the position in which the cars were found, as well as the testimony of eye witnesses, it appears that the wheels after derailment kept closely in line with the rails and ran on the ties clear across the drawspan and then on the approach for a total distance of 200 to 250 ft. before swerving to the right, mounting or forcing off the outer guard rail and dropping into the river.

It is worthy of note in this place, that by the daily newspapers generally the impression has been spread abroad that the cause of the Atlantic City disaster was a deep mystery. The railway officials are liberally and in fact officially quoted as stating that they are wholly in the dark as to the causes of the disaster.

Now we can fully appreciate that at a time of public excitement, such as attends any such calamity, the tendency is to cover up the causes in the endeavor to shield those responsible for them, and to shrink from pointing out just what features of defective railway practice contributed to cause the disaster. But is this the manly or creditable course? In these days, when public hatred of corporations is growing to ominous proportions, is anything gained by playing the ostrich act of hiding one's head in the sand? Does the public really believe the story that such accidents as that at Atlantic City are inscrutable mysteries? Does not the mere recital of the facts of the Atlantic City disaster show that something must have been radically wrong? Is it an unreasonable demand on the part of the public that every such disaster should be sifted to the bottom, and all the contributing causes ascertained, to the end that the chances of its recurrence under similar circumstances elsewhere may be lessened?

It is not our function to place the responsibility for the loss of life at Atlantic City. It *is* our duty to lay before the engineering profession the salient facts in connection with it, to the end that practice may be improved in every matter wherein this disaster has shown danger to exist. It is no less the duty of the engineer and railway manager to be guided by every such occurrence toward better and safer methods and appliances. To hide from the public, and particularly the engineering public, the facts regarding such disasters and make impossible the drawing of useful lessons from them, is little less than a crime against public safety, a crime whose fatal consequences are seen in the enormous accident and fatality record of American railways.

In studying the electric equipment of the West Jersey & Seashore R. R. Co.'s Newfield line between Camden and Atlantic City, of which we are enabled to give a description elsewhere in this issue, one's curiosity is aroused as to the motives which prompted the company to enter into this large expenditure. And this curiosity is not unnatural, for the "conversion" of steam railways to electric traction has been talked about very much, and practised very little. Between the arguments of those who proved that electric traction is the sole and infallible remedy for all diseases of railways and an excellent tonic where no disease is evident, and the arguments of others who denied the feasibility of getting any sort of traffic over the line at all without the old reliable "power-house on wheels"; between these arguments only one patent fact has appeared, namely, that all directors and managers of railway properties are "from Missouri," and require to be shown the profit in sight. The half-dozen cases in the United States where railways have entered into improvements involving electric traction at some point have all been characterized by special exigencies which individualized the case. A good instance is the St. Clair tunnel improvement of the Grand Trunk Ry.; the trouble of tunnel operation by steam locomotives with maximum train-loads and the desire to develop the tunnel's capacity to the utmost were the local determining factors; so much so, indeed, that there is little of general applicability in this case. Almost as striking an instance is the New York terminal electric operation being put in on the New York Central & Hudson River and the New York, New Haven & Hartford. It was virtually forced upon these companies to operate their trains through the terminal tunnel in New York City by electricity, and the great extent of their electrification schemes (to Croton and White Plains on the New York Central, to New Haven on the other) is merely a mechanical or administrative development of this necessity of providing new terminal operating plant.

When we come to the Atlantic City route, however, we discover no such special factors. It is this that leads us to inquire as to the motives behind the work. The company's statement throws little or no light on the matter. But there is a more suggestive reference to it in the last published report (March, 1906) of the Board of Directors to the stockholders of the West Jersey & Seashore R. R. Co. We quote from this document:

> The increasing traffic upon your railroad, as well as the necessity for providing additional tracks and facilities for handling the heavy seashore travel, and affording a more frequent service to and from interior points, has induced your Board, after careful consideration, to approve of the electrification of that portion of your railroad extending from Camden via Newfield to Atlantic City, and from Newfield to Millville. * * * It is believed that these improvements will enable your company to not only move with facility the heavy traffic offered to your lines, but that the convenient and frequent service thus afforded will materially benefit the portion of the State in which your lines are located In view of the results which have been obtained in other parts of the country from the electrification of transportation lines, it was felt that to longer defer the authorization of this work *might encourage other interests to undertake enterprises to the detriment of your company* [italics ours.—Ed.], and accordingly the contracts provide for the running of electric trains during the current year.

We take this passage to mean (1) that the local traffic on the line is of such amount and distribution as to make a frequent service of small units, electric cars and short trains, a desirable thing; and (2) that the threatened construction of competing electric lines forced the company's hand. But the situation is such that one is tempted to speculate on the possibility of another reason: that the electric route to Atlantic City is intended as a large-scale experiment to determine the railway value of electric traction under certain favorable conditions. There is a fairly heavy passenger movement between Philadelphia (opposite Camden) and Atlantic City. By operating a steam line and an electric line in parallel between these points, the company secures

a very accurate comparison between the two kinds of motive-power, which, properly interpreted, should give to the West Jersey & Seashore and to its proprietor, the Pennsylvania R. R., a valuable basis for dealing with subsequent projects for operating traffic by electric traction.

Of course, the two lines will not be under exactly similar conditions. The direct line, via Winslow Junction, operated by steam locomotives, is a high-speed through route, with little local passenger business; on the other hand the Newfield line has a large local business, though it also endeavors to give an attractive through service. A more vital difference between the two lines is the elimination of all but a small part of the freight movement from the Newfield line, which thus becomes virtually a purely passenger railway. The Winslow Junction line carries not only its own freight, but also the freight for Cape May points, taken off the Newfield line. Thus the general operating results of the one line will be those of a mixed freight and fast passenger route, while the results of the other will appertain to a dense traffic of passenger trains and single cars, with almost no freight. It will doubtless be possible to separate successfully the items of the financial results so as to give a valid comparison of earning power. But the point is that the Newfield line will not demonstrate how an electrically-equipped railway behaves under a reasonably heavy freight traffic in addition to normal passenger business.

We trust it is unnecessary to observe that the unfortunate accident at the Thoroughfare drawbridge, where the new electric route enters Atlantic City, has no relation to the fact of electric operation. The published accounts of the accident should not permit any misconception in this direction to arise, but the coincidence of an exceptionally disastrous wreck occurring on a line put into service only a short time before may tend to couple the accident with the motive power in some minds. The fact is that the probable cause of the derailment has nothing whatever to do with the electric equipment, and there is no evidence to indicate that a steam locomotive is safer against derailment, or when derailed is less likely to climb the guard-timber, than an electric motor car of the dimensions used on this line.

RAILWAY BRIDGE FLOORS AND THE ATLANTIC CITY DISASTER.

Nearly twenty years ago there occurred on the Central Vermont R. R. near White River Junction, Vt., an accident which will still be remembered, we are sure, by many of our older readers. On the night of Feb. 4, 1887, a car near the center of an express train was derailed by a broken rail at a point about 400 ft. from the end of a high deck bridge over the White River. The cars behind also left the tracks and ran along over the ties till the bridge was reached, when four of the cars (two Pullman sleepers and two coaches) ran over the side of the bridge and fell to the frozen surface of the river, 75 ft. below. The wreck immediately took fire, and many of the passengers held fast in it were burned to death. The total casualties were some 40 killed and 36 injured.

That disaster had a strong influence in bringing about two important reforms in American railway practice, viz., the abolition of the car stove with the substitution of steam heat from the locomotive and a radical improvement in bridge floor construction.

The last named reform was largely brought about, we believe, through the efficient work of this journal in showing that this terrible holocaust might have been averted if the White River Bridge had been provided with a proper floor and proper guard rails. In our issue of Feb. 12, 1887, a special report on the accident by Prof. Robert Fletcher was presented; and the late A. M. Wellington, then editor of this journal, showed most conclusively that if proper guard rails and portal protection had existed at the bridge, the chances were many to one that the cars would have been guided safely across the bridge and the fatal fall into the river would have been averted.

We have brought forward here this reference to an accident that occurred twenty years ago, because it seems to us that just such an awakening is needed now as happened at that time with respect to safe bridge-floor construction. The terrible wreck at Atlantic City, in which more passengers lost their lives than in the fatal wreck at the White River Bridge, ought to serve, it seems to us, as an object lesson to every railway bridge engineer and to every railway officer who furnishes the means to enable the bridge engineers to do efficient work.

The two points on which we would lay especial emphasis are first, the provision of inside guard rails, and second, the provision of flaring guard timbers and rails at the portal to guide a derailed axle or truck back toward its proper position and if possible restore it to the track by rerailing frogs.

Elsewhere in this issue we have reprinted the description which we published nearly twenty years ago of the standard bridge guard then in use on the New York, Ontario & Western Ry., designed by Mr. J. E. Childs, now its Vice-President and General Manager. Mr. Wellington, in his description, called it "The Best Safeguard Against White River Disasters." We would suggest it to-day as the best safeguard against such disasters as that at Atlantic City.

Further, we desire to submit for the serious consideration of bridge engineers the question whether instead of advancing in the past twenty years our practice in bridge floor construction has not rather retrograded? How many railways to-day have their bridge floors equipped with both outside and inside guard rails and with portal protection such as was standard on the Ontario & Western and on a number of other roads as well, fifteen or twenty years ago? We are not claiming that this arrangement represented perfection; on the contrary, the experience of twenty years ought to have developed something still better; but the unfortunate fact appears to be that we are not to-day doing work anything like as good. What appears to have happened on a majority of roads, if we mistake not, is that the provision of inside guard rails and of flaring guards and rerailing frogs on the bridge approaches has gradually been abandoned, and we venture the guess that the only reason for the abandonment is that to put them in and maintain them made somebody a little trouble and the company a little expense!

If there is any good reason—any reason which will bear keen expert scrutiny—for this change in practice, we shall be exceedingly pleased to set it before the profession in these columns. If, however, our diagnosis is correct and these safeguards are only omitted to save work, then we submit it is high time somebody was "jacked up" and that our American railway bridge practice was jacked up to a higher level. We shall do no more than allude here to the portentous totals of our railway accident record—nothing short of a National disgrace. Our railway corporations have not the excuse of a dozen or twenty years ago, when money was scarce to do anything with. To-day there is certainly money enough in the railway treasuries for every reasonable safeguard to make railway travel secure against loss of life and limb.

We imagine, however, that some of our readers may object that the Atlantic City accident was primarily due to a displaced rail at the end of a drawspan, and consequent derailment of the train. Our reply to this is that this bridge or any other ought to have such a floor that derailed wheels would be guided safely across the structure. Every railway man knows that derailments will occur, more or less frequently. Even with the track in perfect condition, a broken flange may permit a wheel to mount the rail. The sensible plan, therefore, is to protect such danger points as bridges by guards which will save a train with a derailed car from disaster upon them.

If there are any bridge engineers or railway men who believe that a bridge floor with an outer guard timber is as safe as one with an inside guard rail (or timber) we suggest that they make haste to examine into this matter and promptly revise their opinions. It is impossible to successfully defend such an idea. All the weight of authority and experience is against it. As we pointed out last week, a derailed truck which strikes an outer guard timber is given a blow which tends to skew it still further around and compel it to mount the guard timber. The inner guard rail, on the other hand, guides the backs of the wheels at the opposite end of the axle, and insomuch as it retards them it tends to skew the truck in the reverse direction and keep it in line with the wheels on the rail.

It is true that derailed wheels running between the track rail and the guard rail will often snap off many of the spike heads and make some work for the track force; but that is surely better than a wreck on the bridge with resulting casualties. The moral would seem to be a better method of rail fastening than ordinary spikes for use between the track rail and the guard rail.

If any further testimony were needed as to the practical efficiency of inside guards, it is surely furnished by the quarter century record of the New York elevated railways, and by the experience nearly as long with elevated railways in other cities. It is not too much to say that the operation of these railways over crowded city streets has only been possible because the guard timbers have always held derailed trains in place on the structure and prevented them from falling into the street. The single exception occurred in New York two or three years ago when a train was derailed on a sharp curve where the guard timber was necessarily omitted.

Surely with this experience of the elevated railways on record, it canot be seriously claimed that other railways can do no better than they are now doing to keep derailed trains from falling off from bridges or other structures.

As for the provision of flaring guards on the bridge approaches at each end, we see no possible objection to them, and believe that their general use would prevent many serious accidents. That has been the record in the past on roads which have used them, and there is no reason why the same result should not obtain now. The arrangement was developed by practical railroad men. The late Chas. Latimer, who invented and patented the rerailing frog, was one of the ablest American railway engineers of his time in all matters relating to permanent way. His patent long ago expired and any railway company can cast these frogs in its own foundry at trifling expense.

The objection has sometimes been raised to inside guard rails, brought to a point in the center of the track, that a derailed wheel more than half the gage out of line will be deflected still farther to one side and a wreck may be caused thereby. In practical experience, however, derailed wheels which follow along the roadbed and do not at once swerve to one side, are very seldom as much as half the gage out of line. Further, any such wheel or truck will be guided back toward the center by the flaring outside guard timber, which should extend out on the bridge approach considerably beyond the point of the inside guard rails.

We have alluded above to the idea that a period of twenty years ought surely to have witnessed some advancement toward safer and better construction of railway bridge floors. If the Childs-Latimer bridge guard represented the best practice 20 years ago, then something much better ought to represent the best practice of to-day. But if anything better has been actually put into use anywhere, we are unaware of its existence. We do recall a design made by the late General Serrell for the proposed Peekskill bridge over the Hudson, which was never constructed. In this design the rails of the bridge were laid in steel channels with their flanges up, according to our recollection. Thus any derailed wheels would drop into these channels and roll smoothly in them across the bridge. It would, of course, be a simple matter to arrange

flaring guards at the ends of the bridge approaches to guide derailed wheels into alinement so that they would enter these channels. We believe that some such plan, providing a continuous steel trough for derailed wheels to roll in across a bridge, is preferable to the plans of letting derailed wheels bump from tie to tie.

We have no expectation, however, of seeing any such radical improvement adopted, except possibly in the case of isolated structures of great importance. Nor do we especially urge such a practice since experience has shown that derailed wheels will roll without serious difficulty over an ordinary bridge floor with ties spaced not more than 4 to 5 ins. apart and properly blocked to prevent bunching.

What we do urge, with all possible emphasis, is that proper attention be given to the matter of bridge guards. Don't sell worn rails for scrap so long as there exists a bridge or a trestle or a high embankment where those rails might be laid and add additional safety to train movement. Don't be deluded with the idea that an outside guard timber on a bridge is sufficient protection until you have examined the many authorities who years ago testified to the great advantages of inner guard rails. Don't expose yourself to the chance of wrecking a train load of human beings by failing to take care of derailed wheels on bridge approaches. You cannot wholly prevent derailments. They have been with us from the beginning of the railway era, and are pretty certain to remain. You can, however, reduce to a minimum the chances of serious disaster through derailments on bridges, and you are derelict in your duty if you neglect to do this.

TYPHOID FEVER AND WATER FILTRATION AT WASHINGTON, D. C.

Surprise and disappointment are tame words to express the feelings of many people in and out of Washington on learning that the new water filtration plant was not effecting the confidently-expected reduction of typhoid fever in the National Capital. For twenty years or more the typhoid death rate in Washington had never fallen as low as 40 per 100,000, while in 1890 it had reached 104, and much of the time thereafter and until 1903 it had ranged from 65 to 80. It was believed, and there were good reasons for believing, that the high typhoid mortality was due to the polluted condition of the public water supply, drawn from the Potomac River, and for ten years a persistent agitation for filtration was kept up. Slow sand filters, embodying the most advanced ideas in water purification, were put in full operation early in October, 1905. Some months afterwards, when the filters were in good running order, and when it was reasonable to expect that the unfiltered water in the piping system of the District had been replaced by filtered water, an examination showed that the deaths from typhoid fever were running about the same in 1906 as in the corresponding months of 1905, and that the cases numbered considerably more. Sensational reports were telegraphed over the country, and not a few daily papers spread and gave high color to the story that the "$3,000,000 filtration plant" at Washington was a failure. The story has been seized upon by opponents of proposed filtration plants in several cities, and already it has caused no little honest questioning among laymen and embarrassment to engineers and health officials.

It was immediately evident that a knowledge of the actual facts in the case was of the utmost importance to the readers of Engineering News, for either great injury was being done to filtration and to the advance of sanitation, or else, in case the filters were really at fault, something must be wrong in the design and operation of the filters. If, however, the filters were in no way responsible for the unfortunate continuance of the high typhoid mortality in Washington, it was of the utmost importance that the fact be established, in order that the real danger, at Washington or under like circumstances elsewhere, might be found and combatted. The actual facts and their proper interpretation are all the more significant because they relate to the National Capital, which, in all matters pertaining to public sanitation, should certainly be not only a safe place for its inhabitants and its many visitors but also a model for every other city in the country. In view of the foregoing and many other reasons, Engineering News felt it a duty, which it gladly undertook, to have made for the benefit of its readers a careful study of and report on the Washington typhoid fever situation. The results of this study are presented at length elsewhere in this issue. The investigations were made by Mr. Theodore Horton, M. Am. Soc. C. E., Consulting Engineer of the New York State Department of Health, and until recently for many years with Messrs. Rudolph Hering and George W. Fuller, M.'s Am. Soc. C. E. Mr. Horton, both in the conduct of his local investigation and in the preparation of his report, had, at the request of this journal, the counsel of Prof. William T. Sedgwick, of the Massachusetts Institute of Technology. Professor Sedgwick needs no introduction to those readers of Engineering News who have followed sanitary science, but for the benefit of others who are interested it may be said that he stands at the front of the epidemiologists and sanitarians of the day, particularly as regards the causes and the means of controlling the spread of typhoid fever outbreaks. Following Mr. Horton's report will be found some comments on it, and on the Washington problem in general, by Professor Sedgwick.

We consider it particularly fortunate that in this very issue we are able to present, alongside of the articles by Messrs. Sedgwick and Horton, a somewhat detailed description of the Washington filtration plant, based on a paper by Messrs. Allen Hazen and E. D. Hardy, M.'s Am. Soc. C. E., presented only last night before the American Society of Civil Engineers. Although rendered doubly interesting by the typhoid situation at Washington, the paper by Messrs. Hazen and Hardy is a most notable one by itself. We wish in particular to call attention to its description of the underdrainage system of the filters, with their compensating orifices; the reinforced concrete Venturi meter; the unique methods employed in excavating and freeing from clay the sand for the filters; the remarkably low cost (40 cts. per cu. yd.) of scraping the filters, removing, washing and replacing the sand; and the interesting and valuable experiments on the best size of pipes and design of ejectors for removing and washing the sand by the hydraulic process.

Before passing from the paper describing the filter plant we cannot refrain from emphasizing two points which it brings out: (1) The demonstration, whenever the turbidity of the Potomac River water is high, of the need for preliminary treatment by a coagulant, and (2) the imperative necessity of cutting the consumption and waste to a lower figure than 200 gals. per capita per day. As to the coagulant, it may be explained that its necessity, at times, was urged by every engineer who took a prominent part in the investigations leading up to the establishment of a filter plant, and that only the well-meant but misdirected zeal of some of the physicians of Washington prevented the inclusion in the design and construction of means for introducing a coagulant when the turbidity is at its worst. Even now a relatively small sum would be sufficient to meet the cost of a coagulation adjunct to the filter plant.

Reverting to the reports by Mr. Horton and Professor Sedgwick, it will be seen, in brief, that they agree in attributing the continued high mortality from typhoid fever at Washington, since the filter plant was put in use, to other causes than the public water supply: or, in other words, the filter plant, in their judgment, is in no way responsible for the continued high typhoid mortality. With this conclusion, in the light of the evidence thus far available, we most heartily agree.

It should be understood that Washington is not suffering from an epidemic of typhoid fever, but that since the filtration plant was put in operation the typhoid mortality has been much lower than the average for nearly twenty years before that time. The years 1903, 1904 and 1905, however, showed a marked decrease over previous years, and it was expected that in 1906 the rate would fall still further until it reached the figure commonly recorded in communities having pure water supplies. Instead, it now appears that the average of about 44 typhoid deaths per 100,000 for the three previous years will be slightly exceeded in 1906.

We have frequently maintained that for the country at large the excess of typhoid fever over a death rate of 20 per 100,000 per annum should be attributed to an impure water supply. In applying this assumption to specific cities, the normal typhoid rate, using the word normal to indicate typhoid due to other causes than water, must of course be varied with local conditions. In many, if not most, Southern cities it appears that a normal typhoid rate higher than 20 must be assumed, and the indications are that Washington falls most decidedly in the Southern class. Just what its normal or non-water rate should be assumed to be, it is risky to predict until a more extended study has been made of the peculiar conditions prevailing in Southern cities in general and in Washington, if they really exist there, in particular. Mr. Horton and Professor Sedgwick believe that the unusual period of sedimentation which precedes filtration at Washington, and which was increased shortly before the filters were put in operation, virtually discounted the effect of the filters upon the typhoid death rate, although leaving a material amount of infection for the filters to remove. That this further reduction has not followed a year of filtered water must be attributed, in the opinion of our investigators, to the fact that the relatively small reduction by filtration has been more than counterbalanced by the increase this year, as compared with the three previous years, due to causes other than the public water supply. Where typhoid has prevailed for many years to the degree that it has at Washington, there appear, as Professor Sedgwick so happily expresses it and as Mr. Horton's diagrams so graphically show, waves on the ocean of typhoid. The possible absence or diminution of these waves in the three years 1903-5, combined with the reduction in typhoid attributed to increased sedimentation, apparently cut down the typhoid rate, while the oncome of a wave in 1906, due to other causes than typhoid, has raised it again, though to nothing like its earlier figures, which were frequently from 60 to 80 or more per 100,000. Had not one of these waves (due to other causes than water) been raised, typhoid in Washington for the present year might have gone down to 30 per 100,000. We venture to predict that within a few years it will go to that figure, if not to 25, provided that Dr. Woodward, the efficient Health Officer of Washington, is armed with money, men and ample authority to study and combat the perplexing causes of the typhoid remaining in Washington.

We believe that the experience of Washington will mark a turning-point in the fight against typhoid fever in America, and will at the same time shift upon municipal health departments some of the responsibility for the prevalence of that disease heretofore placed upon water departments and water companies. Health departments, at the same time, will be compelled to shift some of the responsibility for excessive typhoid upon the general public, or at least upon those careless individual members of it who fail to avail themselves of the protection against contaminated milk and other foods afforded them by efficient health departments and fail also to observe the laws of prudence and decency and protection to their families and outsiders when typhoid invades their own homes.

The numerous water-borne typhoid epidemics in the United States, of late, and the shockingly high typhoid death rates in many cities known to have seriously polluted water supplies, combined with many instances of marked reductions

in typhoid that have followed the introduction of pure water, by filtration or otherwise, have all combined, not to place undue importance on pure water, but to divert attention from the other causes of the spread of that disease. The lack of complete vital statistics, and particularly the failure of many cities to secure from physicians prompt notification of all cases of communicable disease and the further failure to make full and proper use of such notification, including the making of "bedside investigations," have rendered it generally impossible in the past to determine with certainty upon whom or what the responsibility for excessive typhoid rested. Until we have more light upon the subject we must assume that a city whose water supply as delivered to consumers is free from suspicion of pollution must turn elsewhere than to the water department for the means that will effect a reduction of a high typhoid death rate; and this will be particularly true wherever the water supply is filtered in accordance with the latest practice and shows comparative freedom from bacteria.

In the present or Washington case the pollution of the water supply is far less, judged from relative populations on drainage areas, than in many cities, American and foreign, where the introduction of efficient filtration plants has invariably effected marked reductions in the prevalence of typhoid fever. In view of this, it is manifestly unfair to lay the blame for high typhoid in Washington upon the new filters there until as scientific methods of judging the innocence of all other means of typhoid infection have been applied to them as have been applied to the filtered water supply of Washington.

In conclusion we wish to say, in justice to Mr. Horton and ourselves, that we did not ask him to carry his investigation farther because the U. S. Public Health and Marine-Hospital Service is making an exhaustive study of typhoid in Washington. This it has undertaken at the request of Dr. Woodward and the other responsible authorities of the District of Columbia. A commission of three eminent members of the Service, working under the direction of Surgeon-General Walter Wyman, and with extensive laboratory and other facilities at its command, has been at work since July 1, 1906. It is expected that the commission will make an exhaustive report on its findings. It has therefore seemed advisable for us to confine ourselves to the main facts regarding typhoid and filtration at Washington, awaiting the report of the commission for further details and particularly for the results of minute scientific studies of the various obscure and perplexing phases of the problem. We are presenting at this time such facts as could be gathered with a reasonable assurance of reliability, in order that our readers might draw their conclusions therefrom instead of relying upon the sensational press reports that have condemned out of hand what there is every reason to believe is one of the best, as it is the largest, filtration plant yet put in operation in the United States. Until the report of the U. S. Public Health and Marine-Hospital Service appears, we hold subject to modification by the evidence there presented all the suggestions and conclusions which we have advanced in the course of this article, and doubtless Professor Sedgwick and Mr. Horton have the same attitude regarding their comments and conclusions. We understand that the report will be completed in about a month and will be perhaps the most exhaustive study of its kind ever made.

CUTTING OFF STEEL PILES BY ELECTRICITY is one of the novel sights pointed out to New York visitors at Broadway and 25th St. Heavy interlocking steel piling is there used on the foundation work for the new Hoffman House. Owing to the unevenness of the rock below, the piles project at different heights above the proper level. The electric current is used in place of tools to cut off the tops of the piles, on account of the saving in time and money resulting from the use of the former method. Alternating current from the street mains is employed. The voltage is stepped down to 50, and the current applied to the steel by carbon electrodes quickly burns its way through. Masks of asbestos and smoked-glass goggles are worn by the workmen to protect them from the heat and glare caused by the current.

THE PREVALENCE AND CAUSATION OF TYPHOID FEVER IN WASHINGTON, D. C.

By Theodore Horton,* M. Am. Soc. C. E.

The prevalence of typhoid feven in Washington, D. C., or more strictly in the District of Columbia, during the past thirty years, has probably been made the subject of more study and inquiry from the standpoint of epidemiology than any other infectious disease, or of this particular disease in any other locality in our country. It has been investigated and reported upon from time to time by various commissions appointed in the District to study into its causation, either as a general problem, or in relation to specific outbreaks, and in more recent years it has been especially studied with respect to the introduction of the present new supply of filtered water.

The persistence of the disease in the District of Columbia since the completion and operation of the new filtration system in October, 1905, has given rise to considerable concern, if not at times actual anxiety, at Washington, and has unfortunately afforded opportunity for the spread of sensational press reports through the country reflecting discredit not only upon the management of the filter plant but also upon its very existence.

So little information from an authentic source has, up to this time, been available, and so conflicting have been the reports, that on behalf of Engineering News the writer was engaged to visit Washington and make an investigation to determine the exact nature and prevalence of the disease and, if possible, to discover any specific cause or source of infection. The time available for undertaking this work was inadequate to make as thorough a study of it as was desirable. The writer did, however, spend portions of three weeks, mostly on the ground, acquainting himself with local conditions and gathering vital statistics and other information which might throw light upon this perplexing situation.

Statistics of mortality from typhoid fever for some twenty or more years have been compiled from records of the District Health Officer and were courteously placed at the disposal of the writer. These records were carefully reviewed, tabulated and charted. Records of the operation of the new filters from the time they were put into service were also placed at the writer's disposal and carefully studied. Still other statistics, relating to the amount of pollution upon the Potomac River drainage area, which fortunately had been gathered recently by the U. S. Geological Survey, were in a similar manner made available and studied. Information of a specific nature relating to wells, privies, dairies, shellfish, market and garden truck, etc., were secured in like manner from individuals or officials either engaged in or having control of these various industries. Finally a personal investigation was made of the causation of a few cases of typhoid fever in the District.

The question of first importance was to determine somewhat closely from official records the prevalence of typhoid fever in the District of Columbia during the present year, in order that this might be compared with the typhoid fever statistics of past years and with similar statistics in other neighboring localities or cities. Fortunately, and with much credit to the management of the present District Health Office under Dr. William C. Woodward, complete records for more than 20 years have been compiled, and are now regularly recorded, showing the mortality from typhoid fever and other allied diseases classified under the heading of typho-malarial, malarial and diarrheal diseases. In addition to these mortality records, morbidity records have been kept of typhoid fever for the past four years.

The history of these four classified diseases in the District of Columbia is shown graphically, and in considerable detail, from January, 1885, to October, 1906, by the diagrams, Figs. 1 and 2.

On Fig. 1 are plotted curves showing the yearly mortality from the four diseases just mentioned. The curves represent mortalities per 100,0[illegible] except for diarrheal diseases, in which ca[illegible] the ordinates represent mortalities per 10,0[illegible], or one-tenth the mortality per 100,000. A fe[illegible] explanatory notes relating to wells, privie[illegible] and other features which may show an asso[illegible]tion with these curves are also recorded chron[illegible]gically upon the diagram. These will be re[illegible]red to in later statements.

On Fig. 2 are plotted the deaths from ty[illegible]oid fever in the District of Columbia for each m[illegible]th beginning with January, 1885, and the re[illegible]ted cases of the disease for the past four [illegible]ars. For convenience and the sake of closer com[illegible]rison this morbidity curve was plotted with [illegible]dinates representing one-tenth of the actual [illegible]orbidity; and in this respect shows roughly the amount below or in excess of 10% which the fatality from typhoid fever has been d[illegible]ring these years.

With these historical pictures before us let us trace carefully the changes in the mortality rate from these four classified diseases from year to year and season to season and get clearly in mind what these variations are, in order to discover, if possible, what significance they have when compared with the typhoid fever rate during the present year.

Referring first to Fig 1, and comparing the yearly mortality rate of the four diseases referred to, we observe in general that they all remain about the same or show a gradual increase, from 1885 to 1890. From this date there is a general though irregular decline in all of them up to the present time.

Considering them in more detail, we find that the curve of malarial diseases rises gradually from 22 in 1885 to a maximum of 49 in 1891, and then falls to about 4 in 1903, after which it does not materially change. The typho-malarial curve shows a similar but more striking history, in that it rises from 12 in 1885 to a maximum of 14 in 1889, and then steadily decreases to zero in 1904, after which it fails to be recorded—indicating clearly the ill-defined nature of the disease and the probability that under improved methods of differential diagnosis in later years it has been classified either as typhoid or as malarial fever. The curve for diarrheal diseases does not show this fluctuation in so marked a degree, probably owing to the greater number of deaths recorded, which would tend to keep the average more uniform. The general decline after 1892 is, however, apparent.

The curve for typhoid fever, though following in a similar way the variations of the other curves, is strikingly more erratic. In a general way, however, it rises from 56 in 1885 to a maximum of 104 in 1890, and then declines to about 45 in 1903, after which it remains nearly stationary. The irregularities are, however, quite marked. The mortality rate runs quite uniformly for a period of a few years, as for instance from 1891 to 1895, and from 1903 to 1906, while for the intervals between these periods the curve is so irregular as to possibly lead one to consider the disease epidemic if the records of one year are compared with those of only the preceding or succeeding one.

Referring to Fig. 2, which shows the seasonal distribution of typhoid fever, we find even more striking features. Taking, for instance, any one year, we find a very marked fluctuation during the different months. Beginning with about May, the curve rises gradually, reaches a maximum in August or September, when the mortality rate is about four times that during the spring months, and then declines steadily until the following January, remaining about stationary from this month until the following May.

The relation of the seasonal variation of the mortality from typhoid fever with the seasonal temperature has been carefully studied by Liebermeister in Germany and, for different localities, by Sedgwick and Winslow in this country, and so important is this relation to the problem at Washington that Fig. 3 has been prepared to show this relation. This diagram gives the average mortality from typhoid fever for each successive month of the year for the past twenty

*Consulting Engineer New York State Department of Health, Albany, N. Y.

years and the average of the mean monthly temperatures for each month for the same period. For additional comparisons, the diagram also gives the average of the monthly relative humidities and monthly rainfalls for this period. These four curves, then, show any relation which

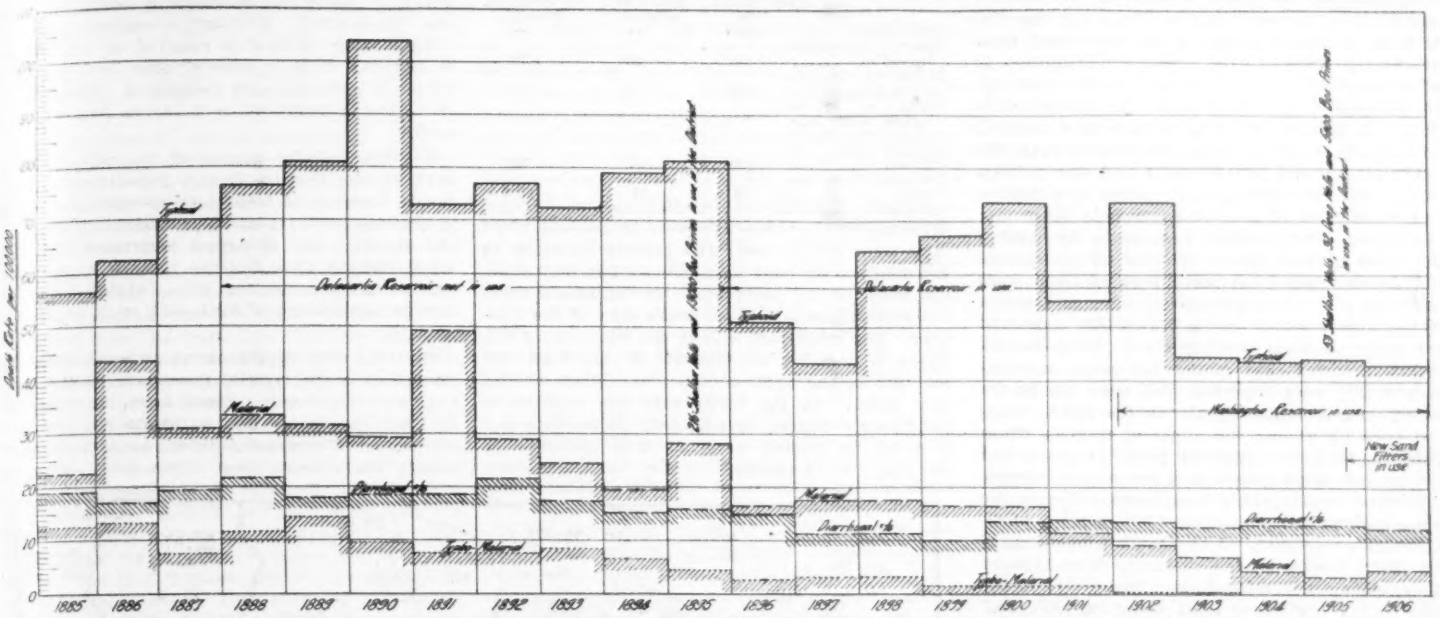


FIG. 1. DEATHS PER 100,000 PER YEAR FROM TYPHOID, TYPHO-MALARIAL, MALARIAL AND DIARRHEAL DISEASES IN THE DISTRICT OF COLUMBIA, 1885 TO 1906.

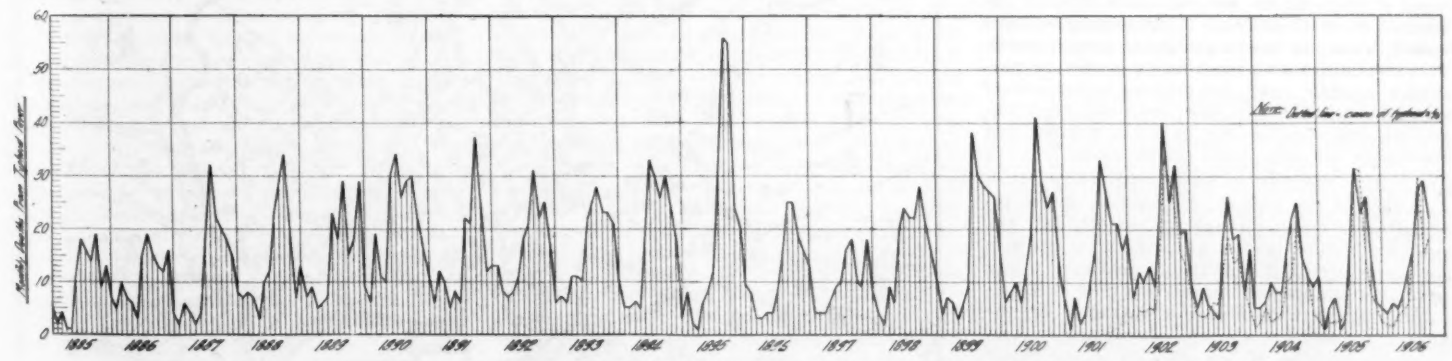


FIG. 2. DEATHS BY MONTHS FROM TYPHOID FEVER IN THE DISTRICT OF COLUMBIA, 1885 TO 1906.

may exist between the seasonal occurrence of typhoid fever and the seasonal changes in meteorological conditions. Considered broadly, there is a marked similarity inherent between the curve of typhoid fever mortality, temperature and rainfall. With the curve of relative humidity this similarity is less marked, though apparent. It is, however, interesting to note that the curve of typhoid fever is distinctly more nearly synchronous with the curve of relative humidity than with the curves of temperature and rainfall, which would seem to indicate that any relation which may exist is one that affects more the fatality than the incidence of the disease.

The typhoid fever curve when compared with the temperature curve displays a remarkable parallelism. The similarity between the two curves is striking, notwithstanding the fact that occasional epidemics of the disease have occurred which would tend to destroy it. If allowance be made for slight irregularities in the typhoid curve, and also for the necessary time which must elapse for infection and incubation of the disease, as well as for the fever period before death, it will be seen that the two curves are almost identical. An important fact is that the parallelism of the mortality curve of typhoid fever with the seasonal curve of temperature has previously been pointed out for the District of Columbia and commented upon by Professors Sedgwick and Winslow of the Massachusetts Institute of Technology in their valuable paper upon the "Seasonable Prevalence of Typhoid Fever" (see Memoirs American Academy of Arts and Sciences, Vol. XII., No. 5. Aug., 1902). The studies of these authors showed that the character of the curves of typhoid fever mortality for the District of Columbia, for the period studied by them, were closely similar to those of cities such as Boston, New York, London and others, which, however different in the amount of typhoid fever present, are all alike in exemption from epidemics of water-borne typhoid fever. I find that the conclusions of these authors for a period of ten years are no less true for the much longer period which I have investigated.

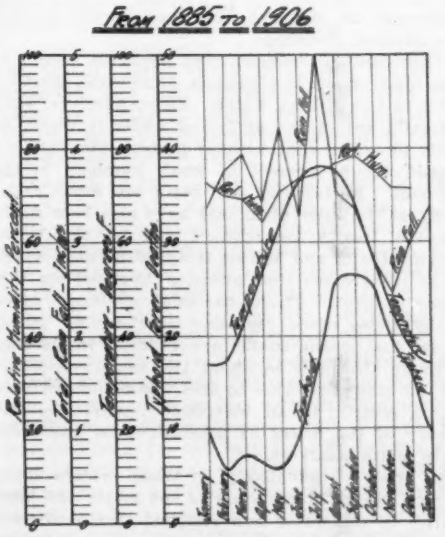


Fig. 3. Comparison of Seasonal Mortality from Typhoid Fever with Seasonal Changes in Temperature, Relative Humidity and Rainfall, 1885 to Oct. 1, 1906.

Returning to a more detailed discussion of the mortality from typhoid fever, as shown by Fig. 2, the important fact appears that, in spite of the operation during the present year of an elaborate and costly purification plant, built for the express purpose of reducing the typhoid fever mortality in the District of Columbia, no such reduction, in comparison with the two years just preceding, as was expected has in fact taken place. In view of this fact, it is not surprising that much disappointment has been felt nor that some have gone so far as to pronounce the plant a failure. Before coming to any such conclusion, however, it is obviously necessary to examine carefully the available data on the prevalence of typhoid fever, not only in the District of Columbia but in similar communities elsewhere.

The total of typhoid fever for any community is always the sum of a number of component factors, such as polluted water, polluted oysters, polluted vegetables and other polluted foods. There is also usually a considerable amount derived from direct contagion, sometimes called "contact" or "secondary infection." A consideration of these various factors in relation to the local conditions studied and observed in the District of Columbia will now be taken up under a series of corresponding headings and briefly discussed. We may first, however, consider the following:

1. DISTRIBUTION AND CLASSIFICATION OF TYPHOID FEVER CASES AND DEATHS.

In general it was found that the cases of typhoid fever were quite uniformly distributed over the entire District—that is, roughly in proportion to the density of population. This fact is more clearly brought out by the accompanying plan of the District (Fig. 4), showing it divided into some 53 sections, of similar area and population, each of which has individual characteristics with respect to local conditions. In

each of the areas are recorded the total cases of typhoid fever reported for the year 1905 and for the year 1906 up to Oct. 17. With few exceptions, and making allowance for cases yet to be recorded during the remainder of the year 1906, it appears that in both these years typhoid fever was prevalent in every section of the District and that in no particular section could the disease be considered distinctly more prevalent than in others. This fact of uniform distribution is of considerable importance in throwing light upon the possibility of any particular foci of infection. It points, in fact, rather to a general infection from either the public water supply, the continued general use of wells and box privies, or the more complex general causes now classed under the head of prosodemic typhoid fever

Another classification was made by taking 200 cases as they appear in order on the records and determining what percentage of them were imported and what percentage were in families of the lower, poorer class, the middle class and the upper or more wealthy class. This classification indicated that of the 200 cases, approximately 12% were imported, 55% were among the lower, poorer class, 30% among the middle class and only 3% among the upper or wealthy class. This would seem again to point to wells and privies and other causes of a prosodemic nature.

Another classification was made between the white and colored population. The colored population is about 30% of the total population of the District, whereas the mortality from typhoid fever among the colored race is nearly double that among the white race, being in 1905, 28.7 per 100,000 for the negroes, and 15.1 for the whites. This is a very important fact, for it gives a much higher typhoid death rate for the District than would occur if the population were mostly white, as in cities situated further north. This classification by races has, however, no particular bearing upon the relative prevalence of typhoid fever for this year, since the conditions are for this year, so far as I could learn, not materially different from recent years.

II. PUBLIC WATER SUPPLY.

In view of the uniform distribution of the typhoid fever cases throughout the District, the apparent failure of the filtration plant to give the expected reduction of the typhoid rate, to say nothing of the specific imputations that were frequently heard regarding the operation of the plant or its value as a means of reducing typhoid fever, the question of the influence of the public water supply was carefully studied.

The new filtration plant was completed and put into partial service in August, 1905, but it was not until October that unfiltered water was entirely excluded. Very complete and elaborate records have been kept of its operation from the date the filters were put into service and these records show to a surprising degree the efficient work of the filters in removing the bacteria contained in the raw water. In order to show this clearly, Table I. is presented, showing the average bacterial efficiency of the filters during the present year. The table gives the average total number of bacteria per cubic centimeter for the months from January to October, 1906, in the raw Potomac River water at the intake at Great Falls; after passing through each of the two natural and one artificial reservoirs located along the aqueduct between the intake and the filters; and the total bacteria in the effluent as it is delivered into the city mains. The efficiencies are expressed in two ways: (1) showing separately the percentage removal by passing through each of the three reservoirs and the filters; (2) showing the total percentage removal as compared with the bacteria in the raw Potomac water.

Two very striking facts are apparent from this table. One is that the Potomac water after passing through the three reservoirs, where it undergoes a high degree of subsidence, and before passing through the filters, shows a reduction of about 93% in the number of bacteria contained in the raw water. An interesting confirmation of this purification is readily obtained by comparing on Fig. 1 the typhoid fever rates during the periods that the Dalecarlia reservoir and

TABLE I.—SHOWING AVERAGE NUMBER OF BACTERIA PER C.C. IN THE RAW POTOMAC RIVER WATER AT GREAT FALLS AND AFTER PASSING THROUGH THE DALECARLIA, THE GEORGETOWN AND THE WASHINGTON RESERVOIRS AND THE FILTER BEDS DURING 1906.

	Bacteria per c.c. Average of months Jan. to Oct., 1906.	Percentage removal due to each separate.	Percentage removal compared with raw Potomac water.
Great Falls	4,900	—	—
Outlet of Dalecarlia Reservoir	1,480	70	70
Outlet of Georgetown Reservoir .	700	52	86
Outlet of Washington City Reservoir (as water passes upon the filters)	300	57	93
Effluent from filters	18	94	99.6

Washington City reservoir were in use and when they were not in use. The periods indicated in the diagram are only approximate but they show the effect of the purification by subsidence upon the general typhoid fever death rate of the District. The other fact is that the efficiency of the filters in reducing the bacteria is very high, being 94% of the applied water, and 99.6% of the raw water. In the latter case the removal is practicaly complete, leaving only 18 bacteria per c. c. in the filtered water as it is delivered to the city. It is needless to say that such completeness of removal has been rarely if ever maintained elsewhere.

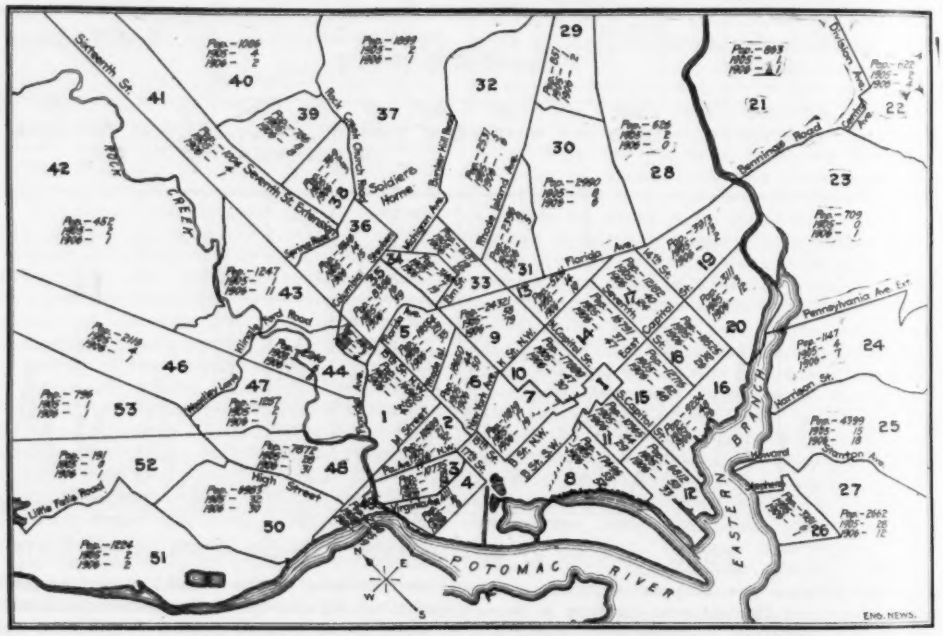

Sixteenth St.
Seventh St.
Rock Creek Church Road
Soldiers Home
Georgia Ave.
Rhode Island Ave.
Florida Ave.
Pennsylvania Ave.
Harrison St.
Howard
Monroe St.
Kenyon
Irving St.
Park Road
Quincy St.
Newton St.
Otis Place
Monroe St.
Michigan Ave.
Hobart Place
Columbia Road
Harvard St.
Irving St.
Webster St.
Lamont St.
Park Road

TABLE II.—SHOWING VOLUME OF OYSTERS AND CLAMS SHIPPED INTO THE DISTRICT OF COLUMBIA AND CONSUMED IN THE YEAR 1905.

	Oysters imported; bushels.	Clams imported; number.*	Cases of typhoid fever reported.
January	42,400	265,000	31
February	14,300	230,000	10
March	27,700	540,000	24
April	16,800	730,000	24
May	4,700	1,265,000	28
June	2,000	500,000	40
July	2,100	860,000	133
August	1,000	385,000	314
September	19,300	240,000	212
October	36,100	370,000	150
November	54,800	265,000	80
December	53,700	253,000	52

*There are about 300 clams to one bushel.

is done before they are shipped to Washington, since none are fattened in the Potomac River near Washington. The clams are taken principally from the salt waters of the lower Chesapeake near Norfolk. The fact that large quantities of oysters and clams are consumed in the District and that some are consumed out of season, and also the fact that some come from sewage-polluted beds, would indicate that shellfish contribute an appreciable share to the typhoid fever in the District.

V. VEGETABLES, FRUITS AND BERRIES.

The quantities of these foods which are consumed in a raw and unsterilized state by the public is unquestionably relatively large. This is especially so of fruit and berries during the summer season. These are brought in from the neighboring rural districts where, as described later, there is a greater prevalence of typhoid and malarial diseases. It is admitted that conditions of truck-farming in this locality, as elsewhere in the South, are often unsanitary. The vegetables and berries are of necessity gathered by hands that are at times infected; if washed at all they are often washed in sewage-polluted waters; fertilizing is frequently done with human as well as cattle manure; and on reaching the markets they are exposed for sale in open stalls and handled in a manner favoring still further infection. The writer carefully inspected a few of these markets and whereas the better ones were attractive and as sanitary as markets generally are kept, he found conditions there, when taken together with the others just enumerated, such as to justify the conclusion that the "garden truck" as collected, exposed for sale, and consumed, without sterilization by cooking, is responsible for a considerable share of the typhoid fever in the District.

VI. PUBLIC WELLS.

In 1895 there were in the District 216 shallow wells, distributed in various sections, but mostly within the city limits. In 1902 there were only 62 of these shallow wells, but in this year the city caused some 40 deep wells to be sunk in the hope of securing better public well supplies and to do away with the shallow ones. In 1906 there were 53 shallow wells and 32 deep wells still in use.

These wells have been frequently attacked by the more zealous local sanitarians as the principal cause of typhoid fever. This view no doubt has been justified at times and in particular cases. Although chemical analyses indicate that the water reaching most of the wells has, at some time, received sewage pollution, both chemical and bacterial analyses made by the District Health Office, and also by the chemists and biologists attached to the filtration plant, show that the water has been thoroughly purified before reaching them. Thus of the 19 deep wells now in use within the city limits, only one showed the presence of coli; and of the 41 shallow wells in the city, only 12 showed the presence of coli, and of these 12 only 4 gave total bacteria in excess of 100.

It is thus evident that the wells now in use in the city can hardly be considered an important factor either in the general occurrence of typhoid in the District or in the continued prevalence of the disease during the year. They were found to be fairly uniformly distributed throughout the District, indicating that there can be no specific prevalence of the disease attributable to any particular well or wells, and further that considering their degree of purity, they can hardly be considered an important factor in the general typhoid mortality of the District. That they should be abandoned, however, is self-evident, for there is always a chance of surface infection and the District now has a much purer and safer water supply than formerly.

VII. BOX PRIVIES.

The question of the influence of box privies on the typhoid fever mortality of the District has always been and continues to be a subject of much speculative thought and opinion. It has been occasionally exploited as the principal cause of the continued presence of the disease in the District and in the judgment of the writer this opinion has been in a measure justified.

These box privies are constructed of wood upon a masonry base and are entirely above ground. Though admittedly water-tight when first constructed their life is short and they soon become delapidated and leaky. Their exposed condition and especially the leakage from them that flows upon or over the surface of the ground serve as a means for the spread of infection either by direct contact or indirectly through the agency of flies.

In 1895 there were estimated to be some twelve to fourteen thousand of these box privies in use in the District. Although there has been, according to official records, an abandonment of some five thousand privies, mostly within the city limits, the records do not show how many new ones have been constructed during the same period. It would probably be fair to assume that some seven or eight thousand of these privies are still in existence, of which probably some four or five thousand are within the city limits.

These privies are very generally distributed over the city and District, and although more concentrated in some sections than in others, there is no clear indication of a greater prevalence of typhoid fever in the sections where these privies are most numerous. Yet when we consider that infection from them is very often indirect, it is not surprising that they show little effect on the typhoid rate. Each privy must be considered as a possible focus of general infection and since the total number of privies runs up to many thousands they doubtless have an appreciable influence in the general spread of typhoid fever.

VIII. PREVALENCE OF TYPHOID FEVER IN OTHER LOCALITIES OF THE SOUTH.

Admitting that the mortality from typhoid fever in the District of Columbia has as yet shown no considerable reduction during the present year over the last two years, and in order to throw light upon the important question as to whether typhoid fever in this section of the country, outside of the District of Columbia, might not be more prevalent this year, and consequently the mortality within the District relatively less, an attempt was made to determine the relative prevalence of typhoid fever in neighboring localities. Such evidence, if it could be accurately determined, would indicate whether the typhoid fever mortality in the District of Columbia was only apparently the same this year as compared with previous years, or whether there was relatively a decrease or an increase over former years.

Although at this season health records for the current year are not generally available, the writer communicated with health officials in Cumberland and Baltimore, Md., Richmond, Va., and Atlanta, Ga., and was himself personally familiar with typhoid fever conditions at Norfolk, Va. Actual statistics were available for Atlanta and Norfolk, and these show that, at Atlanta, the cases of typhoid fever during July, August and September, 1906, were more than the sum of the cases in the corresponding months of 1904 and 1905 combined. With Norfolk the mortality rate for the last summer months was about twice as great as during the corresponding months of any one of the past three years. Dr. Wiley, of Cumberland, states that there is as much typhoid fever this year in Cumberland and surrounding towns as during the last two years combined. Dr. Fulton of the State Board of Health of Maryland states, in a general way, that in Maryland the prevalence of typhoid fever this year is from ¼ to ½ greater than in any of the past few years. Dr. Levy, of Richmond, states that typhoid fever in that city is no greater than in previous years, but gave no statistics of the relative prevalence of the disease outside that city.

Mr. M. O. Leighton, Chief of the Hydrographic Division of the U. S. Geological Survey, states that during the past season the prevalence of typhoid fever in the rural districts of the Potomac River drainage area was studied by his Department and that information was gathered showing that typhoid fever was very prevalent this year over the entire area. The rural districts of the Potomac drainage area are inhabited principally by the poorer of the colored race, and owing to poverty and the lack of medical attendance the disease is not only more prevalent, but reliable information in regard to its prevalence is difficult to obtain except by a house-to-house canvass through the territory. Although the investigation by this Department furnished no statistical information throwing light upon the occurrence of typhoid this year compared with previous years the general impression prevails that typhoid fever is especially prevalent this year.

Although evidence obtained in this general manner is lacking in statistical value, it is, when considered as a whole and in view of its responsible sources, significant as indicating that there has been a greater prevalence of typhoid fever outside the District of Columbia this year than in the past two years, and that the prevalence of the disease in the District this year may be considered relatively less than in the past two years. In fact it strongly suggests that the additional purification of the public water supply resulting from the operation of the new filtration plant has already caused to some extent the expected decrease in the typhoid fever.

IX. RESULTS OF PERSONAL INVESTIGATION OF A FEW CASES OF TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

With a purpose of getting a more definite idea of the causation of the typhoid fever which prevails in the District of Columbia at present, as well as to secure additional light as to the proportion of cases that might have been imported, or be due to secondary infection, the writer made a house-to-house canvass of a number of cases where recovery occurred. These were taken somewhat at random from the records, but in such a manner as to include cases among the poorer class, the middle class and the more wealthy class of citizens:

Case I.: Middle Class, female, age 40. Boarding-house keeper. Sickness in July, treated in hospital, case normal. Public water supply, local milk dealer, no oysters and few raw vegetables eaten prior to illness. Surroundings sanitary. Visited family with case of typhoid fever at intervals for some weeks prior to sickness. Two convalescents from typhoid as boarders prior to sickness. Case apparently secondary.

Case II.: Middle Class, male, age 16. Sick in July. Absent from home in western Maryland for five weeks. During the time roomed with companion who also contracted typhoid fever and died. Case apparently imported.

Case III.: Upper Class, girl, aged about 18. Date of sickness, July 10. During six weeks prior to illness had visited two weeks at Roanoke and ten days at Rockville, Md. Five other cases occurred in same family in following order: July 16, July 18, July 22, July 25, and August 6; all recovered. Case apparently imported.

Case IV.: Upper Class, male, age 40. Banker. Date of sickness, August 1. Not out of city prior to sickness. City water, local milk dealer. Surroundings sanitary. Did not eat raw vegetables nor oysters. No association with any other typhoid cases. Cause not clear.

Case V.: Upper Class, female, age about 18. Date of sickness, July 15. Society girl who visited many section of the city. Ate a great deal of lettuce and salads, little milk and no oysters prior to illness. During one visit drank

water noticeably offensive. Drank water from public hydrant when playing tennis. Surroundings sanitary. Cause not clear.

Case VI.: Middle Class, male, age 40. Date of illness, July 15. Made trip by boat to Baltimore for few days, latter part of June. Fond of fish but did not eat oysters at this season. Public water supply, except on boat at Baltimore; milk from local dealer, except on trip. No association with other cases of typhoid fever. Cause not clear.

Case VII.: Lower Class, German, age 8. Date of illness, August 15. Surroundings very unsanitary—small baking and grocery shop. "Provisions bought where obtained the cheapest." Ate freely of provision and drank freely from two public wells. Not associated with other cases of typhoid fever. Cause not clear.

Case VIII.: Lower Class, colored, male, age 8. Date of illness, July 25. Visited at Rockville, Md., for two weeks prior to illness. Surroundings sanitary except wet cellar. Case imported. Mother said infection received at Rockville (note that Case III. visited Rockville). Case probably imported.

Case IX.: Lower Class, colored, male, age 14. Date of illness, Sept. 10. On visit to Culpepper, Va., for three weeks prior to illness and brought home sick. Case imported.

Time was not available to make a more thorough or extended canvass, which is much to be regretted in view of the large percentage of imported cases among so few investigated. Enough was learned, however, to indicate that a considerable number of cases which are reported are the result of importation (due in large measure to the rather general custom of "visiting in the country"—a custom not confined to the upper classes but extending also to the lower classes) or else received infection through the many channels associated with unsanitary surroundings; i. e., exhibit prosodemic typhoid.

SUMMARY AND CONCLUSIONS.

In view of the many factors which have exerted an influence upon the causation of typhoid fever in the District of Columbia and the rather complex relation which they bear to the continued prevalence of the disease during the year, it may be well to summarize the results of the foregoing facts and studies into a series of conclusions, as follows:

(1) The mortality from typhoid fever, as well as allied diseases classified as typho-malarial, malarial and diarrheal diseases, has decreased steadily, though in an irregular manner, from 1890 to the present year; the causes for which appear to be due to a number of factors. Of these the principal are:

(a) A purification of the water supply by subsidence in one or more of the storage reservoirs.

(b) A decrease in the number of public wells and box privies in the district.

(c) A closer supervision and control of the milk supply of the district.

(d) Other minor and more general improvements in the sanitation of dwellings, better medical care, etc., etc.

(2) During the present year, as shown by the records, the mortality and morbidity from typhoid fever have shown no considerable reduction as compared with the past two years.

(3) From as reliable sources as could be obtained, there appears to be an unusual prevalence of typhoid fever in other portions of the country outside of the District of Columbia during the present year, which would indicate that the prevalence of typhoid fever within the District of Columbia has been relatively less.

(4) The high bacterial efficiency of the new filtration plant and the low number of bacteria in the effluent are prima facie evidences of the high degree of purity of the public water supply. This clearly indicates that the new filtered supply cannot be considered as contributing in any appreciable degree to the continued prevalence of typhoid fever in the District, but, on the contrary, it has probably been the sole cause of keeping down this typhoid fever rate during this season, when the disease has shown an unusual prevalence in localities outside of the District of Columbia.

(5) The water from the Potomac River drainage area, having a resident population upon it of not more that 40 persons per square mile and purified by sedimentary storage basins to the extent of a 75% to 90% removal of bacteria, has probably never influenced to the extent commonly supposed the typhoid fever rate of the District, except at times when these reservoirs were not in use.

(6) The continued high typhoid mortality in the District is due to a number of causes, some of which are complex. Among these may be mentioned the following:

(a) A relatively large proportion of imported cases are contracted during the customary summer visits of a large number of all classes of inhabitants of the District. Dr. Kober estimates the cases attributable to this infection to be from 15 to 20%. In the opinion of the writer this is not an overestimate, and perhaps is an underestimate.

(b) Occasional infection due to public wells, especially shallow wells subject to frequent surface contamination.

(c) Serious infection from box privies which admit of the spread of disease through the agencies of flies, etc.

(d) Infection through the medium of the milk supply which, though subject to careful inspection, is, under the customs of handling now prevailing in Washington, a continued source of infection. That outbreaks do occur with periodic frequency is substantial proof of this. Dr. Kober estimates that milk is probably responsible for 15% of the cases of typhoid fever in the District.

(d) Infection through the medium of oysters. This cause undoubtedly plays a larger share in the infection by typhoid fever than has been previously accepted. Recent investigations by Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, have shown very clearly that the ordinary cooking of oysters and clams removes a relatively small percentage of the infection. The oysters come largely from sewage-polluted beds, are eaten in large quantities and certainly account for a number of cases.

(f) Infection through the eating of unsterilized vegetables, fruit and berries. These are consumed in large quantities, especially in the summer, and the sources of infection are many: starting with the fertilization of the soil with human manure, then the gathering by persons who are compelled to nurse patients in the country, and finally the exposing of them in the markets to infection by flies.

(g) A host of other means of infection of a complex nature by which germs are transmitted from the intestines of one victim to those of another through routes which are so many and diversified as to defy detection.

(7) Although there is strong presumptive evidence that the filtration plant has already exerted an influence in preventing a greater prevalence of typhoid fever during its operation this year, and that, as was the case with the filter plant at Lawrence, Mass., it will show in future years a more marked reduction in the typhoid fever rate of the District of Columbia, any hope for a permanent additional reduction of typhoid fever in the District must be looked for in further improvements in house sanitation, abolition of wells and privies, more effective oversight and control of the milk supply, more vigorous enforcement of disinfection during typhoid fever illness, and a reduction of the more varied and complex causes of infection inherent in the daily lives of the people, especially the lower and more ignorant classes.

The writer, in closing, wishes to acknowledge his appreciation of the courtesies extended by the following gentlemen in placing at his disposal official records and other information indispensible to his studies: The District Health Officer, Dr. Wm. C. Woodward, and assistants; Surgeon-General Walter Wyman and Mr. M. J. Rosenau, M.D., of the U. S. Public Health and Marine Hospital Service; Mr. M. O. Leighton, Chief of the Hydrographic Division of the U. S. Geological Survey; Lieut. E. N. Dent and Messrs. [illegible] B. Hardy and F. F. Longley, of the Washington Filtration Plant; J. S. Fulton, M.D., Secretary of the Maryland State Board of Health, Baltimore, Md.; Prof. Geo. M. Kober, M.D., Washington, D. C.; E. C. Levy, M.D., Chief Health Officer of Richmond, Va.; W. W. Wiley, M.D., Cumberland, Md.; and W. R. Hall, Hydrographer, U. S. Geological Survey, Atlanta, Ga.

COMMENTS UPON MR. HORTON'S REPORT AND UPON THE TYPHOID FEVER SITUATION IN THE DISTRICT OF COLUMBIA.

By William T. Sedgwick.*

In view of the extraordinary importance of the problem of typhoid fever in Washington I have examined with interest Mr. Horton's paper [immediately preceding.—Ed.] and have discussed with him in detail its various aspects.

In the course of a series of studies upon the seasonal prevalence of typhoid fever in the United States and elsewhere, in 1889, I became interested in the question of typhoid fever in Washington and, in collaboration with Mr. (now Professor) C.-E. A. Winslow, in 1902, compiled, plotted and published† curves of average temperature and typhoid fever in the District of Columbia for the ten years from July 1, 1887, to June 30, 1897. These curves showed not only the actual average monthly percentages which the typhoid fever deaths were of the total deaths, but also by their form revealed a close similarity between seasonal typhoid fever mortality in the District of Columbia and that in cities, like Boston and New York, having good water supplies. All of these curves, however, represented averages, and there was still reason to believe that a considerable amount of typhoid fever in the District of Columbia was due to the public water supply. In particular, a notable epidemic which occurred at the end of 1889 and the beginning of 1890, was definitely and, as it seems to me, ably and accurately traced by Dr. (now Professor) George M. Kober, of Washington, to an infection of the water supply by an extensive outbreak of the disease on the Potomac River, in Cumberland, Md. In spite, therefore, of the striking testimony of the decennial curve of typhoid fever mortality just referred to, the writer, like most students of typhoid fever in the District of Columbia, has felt that a considerable portion of that disease has been justly attributable to a polluted water supply. In common, also, with many others he has been surprised and disappointed to learn that the installation of a new, and in many respects a model, filter, for the express purpose of purifying the water supply, has not been immediately followed—as was expected—by a conspicuous and extensive reduction in the typhoid fever morbidity and mortality among the users of the water in the District of Columbia. He has therefore examined Mr. Horton's report with unusual interest and attention.

Mr. Horton's diagrams show that, during the whole period covered by them, typhoid fever in the District of Columbia has been excessive in amount, as compared with many cities of similar size, and that it is still excessive. Nothing is so plain as that during the entire period the typhoid mortality, although fluctuating to some extent, has never fallen below 43 per 100,000, while during a large part of the period it has risen far above this point, and in 1900, during the epidemic in Cumberland, reached its maximum, namely, 104 per 100,000.

We naturally inquire, first, What is the cause of this constant excess, and, second, What is the cause of the fluctuations—the waves—upon this great sea of typhoid fever mortality? One at least and the largest of these waves, as just stated, is already accounted for by the Cumberland epidemic, and, since river pollution is the clear and positive explanation of one wave, we shall naturally suspect that it may have something to do with the others. This suspicion is

*Professor of Biology, Massachusetts Institute of Technology, Boston, Mass.

†Memoirs American Academy of Arts and Sciences, Vol. XII., No. V., pp. 521-571. With plates. Boston, 1902.

strengthened when we observe that during the time of this epidemic, and also during some other periods of high waves, the storage or "settling" reservoirs appear to have been out of use—for no fact in sanitary science is more elementary or better established than the purifying tendency of storage or subsidence upon sewage-polluted water. It would appear, indeed, from the diagram that it was probably this purifying effect of storage or settling which caused the sudden drop in typhoid fever mortality in the District of Columbia since 1903; and I have no doubt that, inasmuch as filtration is everywhere recognized as an even more effective purifying agency than settling, if it had happened that the Washington filter had been put into operation at the end of 1903 instead of 1905, other things remaining as they then were, the decline of typhoid fever mortality which has taken place since that time would have been equally marked and properly attributed to the operation of the filter. By a curious combination of circumstances, however, it apparently happened that in 1903, while typhoid fever in the District of Columbia was still very high and a model filter was being built to reduce it, changes were made by which more extensive and effective storage was provided, the effect of which was immediately to remove from the polluted water of the river a very large percentage of any typhoid fever germs present at the intake, and thus to forestall to a remarkable and unforeseen extent the burden of removal which the filter was expected to bear. Another consequence of this storage has been the furnishing to the filters of a river water already largely freed from bacteria, so that the percentage reduction, so-called, effected by the filter has been smaller than might easily have been wrought by a poorer filter operating upon a worse water, i. e., upon a water richer in bacteria.

Mr. Horton's Table I. shows that a removal of more than 90% of the bacteria has actually been effected by storage, and this is certainly a creditable showing for an old and familiar process of purification, and I have no doubt that this extensive purification of the Potomac water before it is applied to the filters is the solution of some of the most difficult riddles of the Washington problem.

The question will naturally be asked—granting all this—Why has not the filter further reduced typhoid fever mortality in the District of Columbia? I believe that the answer to this question is simple, namely, that a very large part of the constant excess of that disease, which has existed in the District of Columbia for a score or more of years, has come, and is still coming, from sources other than the Potomac River. In a paper entitled "The Present Relative Responsibility of Public Water Supplies and Other Factors for the Causation of Typhoid Fever," read before the New England Water-Works Association on Nov. 9, 1905, and published in the Journal of that Association, Vol. XX., p. 51, Professor Winslow and myself have considered at length what I believe to be practically the same thing as the question before us, and have there stated the principles which in my opinion lie at the root of the present problem. We have there pointed out that many of the cities of the United States, even after the introduction of pure and unpolluted public water supplies, still suffer from a considerable amount of typhoid fever, an amount to which we have applied the term *residual* typhoid. Any one interested in this pnase of epidemiology should consult the original paper. Here I need only say that after a careful consideration of the facts brought forward by Mr. Horton, I am satisfied that all of the typhoid fever which has existed in Washington since the introduction of the new filter belongs in this class. That the amount is larger than in many other cities having unpolluted or well-purified water supplies is, in my judgment, readily explained by differences in local and racial conditions. (See in this connection a valuable paper on "The Health of Washington," by Professor Kober; "Charities," March 3, 1906.)

The fact that bacilli of the intestinal or "colon" type are frequently found in the effluent of the Washington filters is neither unusual nor surprising, for the same thing is true with other municipal filters of high repute, as, for example, that which has now for many years purified the water suply of Lawrence, Mass., and reduced the death rate from typhoid fever (which in this case was largely water-borne) to a very low level. (See State Board of Health of Massachusetts, Report for 1905, pp. 393 *et seq.*)

The question will naturally be asked, Why, if the settling basins proved so effective in 1904 and 1905, need any filter have been built? To this we may reply that settling, though often effective, is not always trustworthy, and that it was therefore well worth while, even on strictly sanitary grounds, and apart from all questions of turbidity, to provide, in addition to the storage already secured, an additional and more perfect safeguard, even at great expense. That such a filter as Washington now possesses is, in fact, a complete protection from polluted drinking water, the experiences of London, Hamburg, Lawrence, Albany and many other cities abundantly prove.

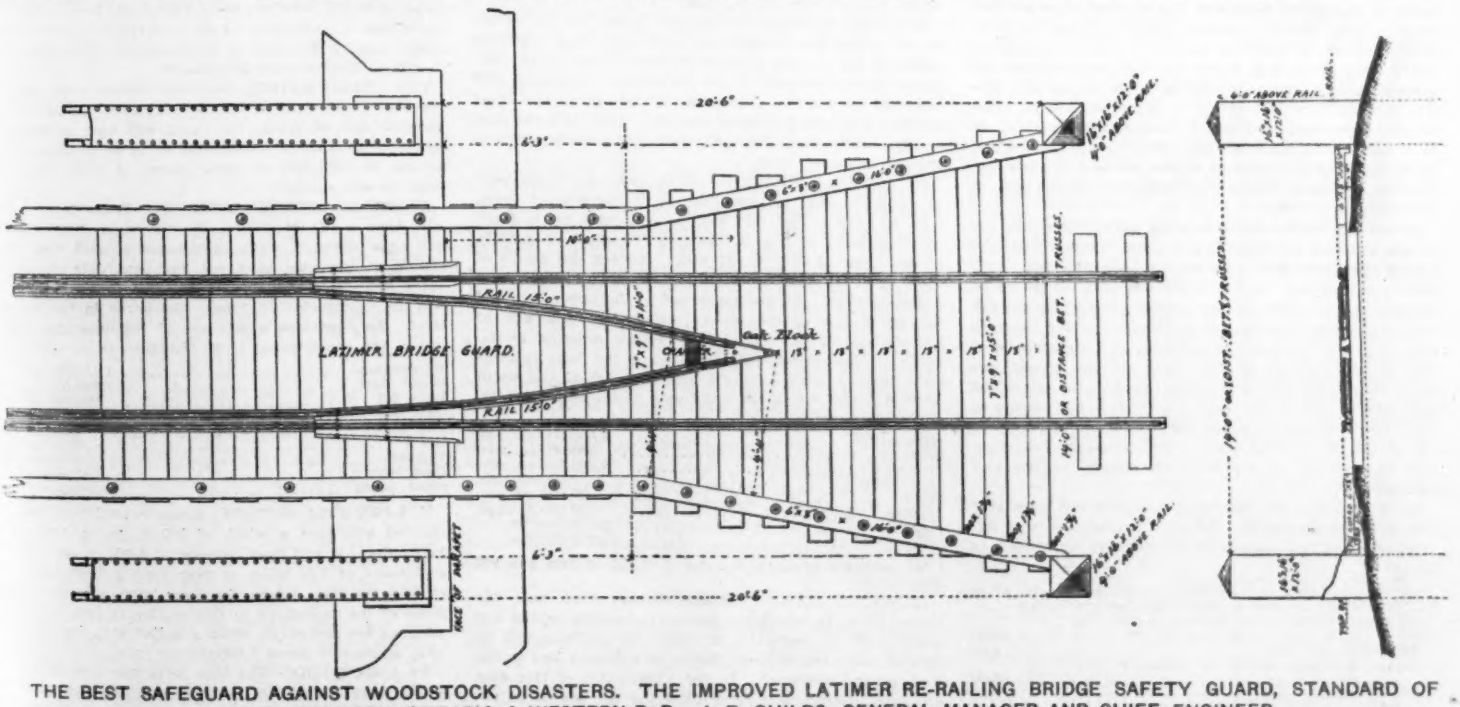
Early in the summer just past I visited and examined the Washington filtration plant. It then appeared to me to be the best example extant in the United States of a great municipal filtration plant, scientifically constructed and skilfully, conscientiously and intelligently operated. I was informed that the average output of bacteria at that time was only 17 per c. c., an exceedingly low number, but one which I am informed has been steadily maintained up to the present time. I have not, since my visit, learned of any reason which causes me to doubt that the filter, ever since it got fairly to work, has purified the river water as effectively as do similar filters at Hamburg, Lawrence and Albany. On the contrary, it seems to me that in its bacterial and hygienic efficiency it is probably as nearly perfect as any filter in the world to-day. The causes of the excess of typhoid fever still remaining in the District of Columbia are, therefore, in my opinion, not to be sought in any imperfection of the filter, but rather in those residual factors of this disease to which Mr. Horton has sufficiently referred. Boards of Health ought to be given money enough to enable them to devote much more attention than they now give to these residual factors, and when they are able to do this—but not before—we may expect to reduce typhoid fever in the cities of the United States to some such level as it has reached in the principal cities of the German Empire. Until that time comes our cities, even when supplied with pure water, will probably continue to suffer from a disgracefully high death rate from typhoid fever—a disease characteristic of a defective civilization. Great sums are now everywhere spent for improved water supplies and sewerage and similar sums are needed for the larger work required to-day of boards of health.

THE BEST SAFEGUARD AGAINST WOODSTOCK DISASTERS.*

(By the late A. M. Wellington, M. Am. Soc. C. E., Editor of Engineering News.)

The awful disaster of last week lends a painful interest to the cheap protection for the ends of bridges, which we illustrate herewith, on whose proven efficacy we have commented elsewhere. Judging from the results of past experience, it is a most moderate estimate that the chance of saving most of the forty or fifty lives lost in the White River bridge disaster at Woodstock, would have been at least nineteen out of twenty had this safeguard, or even either half of it, been on the bridge.

*Reprinted from Engineering News of Feb. 12, 1887.



THE BEST SAFEGUARD AGAINST WOODSTOCK DISASTERS. THE IMPROVED LATIMER RE-RAILING BRIDGE SAFETY GUARD, STANDARD OF THE NEW YORK, ONTARIO & WESTERN R. R. J. E. CHILDS, GENERAL MANAGER AND CHIEF ENGINEER.
(Reprinted from Engineering News of Feb. 12, 1887.)

For the complete bridge safety-guard really consists of two quite distinct parts, either of which alone is efficient, but both together much more so. The Latimer re-railing safety-guard proper consists only of the cast-iron plates shown in the engraving, just opposite to and between the ends of the bridge trusses, with the two rails coming to a point in the middle of the track. The heavy 16 × 16-in. posts, with the flaring wooden guard-rails connected therewith, are an additional and separate safeguard. Both the Latimer guard and the posts are used separately on many roads, and with great addition to safety. The combination which we illustrate is the design of Mr. J. E. Childs, General Manager and Chief Engineer of the New York, Ontario & Western Railway, now Vice-President and General Manager, on which road it is now standard, and it was being rapidly applied to all the bridges before the recent appalling disaster, which we may be sure will not delay its future use. It is, we believe, the most perfect protection for the ends of bridges which has yet been devised, if not the most perfect which can be devised, since it provides very completely for putting the wheels back upon the rails if they are anywhere within the possibility of control, i. e., between the rails on either side; or if not, for breaking the coupling and probably ditching or smashing up the derailed car on the solid bank, before it has reached the bridge.

The re-railing device proper consists merely of four inclined planes of cast-iron, two inside and two outside of the main rails, and firmly bolted together, as shown, although the strain thrown upon them is not very severe, as by the time the wheels reach them they are under control. The outside planes are flush with the top of the rail for the rear half or third of their length, and the wheel rides up them on its flange; thus making the outside wheel of much the larger diameter for the moment, so that it will tend of itself to roll back upon the track.

The inside plane positively insures this. It begins just before the crotch of the rails gets so narrow that there is not room in it for the entire thickness of a derailed wheel. It then has a very quick rise so as to lift the wheel at once to a position where the tread can work over on to the rail, but after this has once been insured the wheel is left to roll on its tread on the rail and not on its flange, so that the inside plane is at no point within about 1¼ ins. of the top of the rail.

In this way the wheels are put back on the track very gently and certainly. In one instance, about a year ago, on the New York, Pennsylvania & Ohio R. R., a derailed car which had been running on the ties for a long distance (if we recall correctly, nearly half a mile) was put back upon the rails without any one knowing it had been off until the marks were discovered on the ties.

But the defect of the Latimer safety-guard, without further adjunct, is that if the wheels are slewed out of place by more than half the gage, so that they will not catch properly on the oak block at the point, the safety-guard does no good, and in fact may rather do harm (although we have never heard of an instance in which it did) by forcing the wheels still further out of place. For this contingency, as also as a measure of security in case the cars are entirely beyond control or are about to become so, the heavy posts and flaring guard-rails are provided. These posts are placed directly in line with the bridge trusses, or about 14 ft. apart in the clear, and are heavy 16 × 16-in. oak sticks, set 8 ft. in the bank and projecting 4 ft. above it. If the inside wheels are anywhere within the rail except snug up against it, these flaring guard-rails will catch them and bring them up to a position to catch on the central guard-rail points, being carefully spaced so as to just do so with certainty, it being obviously desirable to bring the wheels back as gradually as possible.

Should the inner wheels be snug against the rail, the wheels will still be likely to graze and rebound from the side of the heavy post, and the car body likewise. And, finally, should the car be so far out of place as to be entirely uncontrollable, it will strike forcibly against the post, break the coupling, leave the head of the train an excellent chance for safe re-railment, and probably be so checked and broken up that none of the wreck will reach or pass the abutment, thus affording the imperilled lives in the rear of the train a fair chance of escape as experience has shown, except for the danger of fire. We are unable to see what more or better can be done than this, in the way of protection at bridges, at any cost whatever.

But a glance at the engraving herewith will show that this device is not costly. Without having the exact figures at hand, its cost may be liberally estimated as follows:

500 lbs. cast iron in re-railing blocks, at 1½ cts.	$7.50
1,172 ft. B. M. in posts & guard rails beyond bridge	
315 ft. B. M. in extra lengths of ties.	
1,487 ft. B. M. (say 1,500 ft.), at $30	45.00
26 guard-rail bolts, say	4.00
30 ft. old rail, worth to company, say 1 ct. per lb	6.00
Labor in placing and sundries, say	7.50
Total cost for one end of bridge	$70.00

GENERAL PLAN FOR THE CONSTRUCTION OF THE PANAMA CANAL.

The Isthmian Canal Commission has just issued for the information of intending bidders on the Panama Canal Contract a circular descriptive of the general plan of construction. In general this plan closely follows the lines laid down in the Minority Report of the Board of Consulting Engineers, published in our issues of Feb. 22 and March 1, 1906. The drawings which accompany it are those reproduced in our issue of Feb. 22, and we do not therefore attempt their reproduction again. The schedule of quantities involved in the work has not before appeared in this journal, and we therefore present the substance of this circular below as follows:

The following plan is descriptive merely, and is intended only for the general information of bidders. The quantities of material are only approximate. Even the location and character of structures may be changed. It is, however, expected that approximately exact information will be presented to or collected by the committee of five engineers, who under the proposed contract will estimate the reasonable cost and time for completing the construction of the Canal.

The general type of canal proposed by the minority of the consulting board is to form a summit level about 85 ft. above the sea, which is to be reached by a flight of locks located at Gatun on the Atlantic side, and by one lock at Pedro Miguel with two others at La Boca on the Pacific side; the locks are all to be in duplicate. The summit level will be formed by the construction of a large dam at Gatun and a small one at Pedro Miguel. A second lake with a surface elevation of 55 ft. will be formed on the Pacific side between Pedro Miguel and Panama Bay by the construction of a dam at La Boca, across the mouth of the Rio Grande, and another dam between Sosa Hill and high ground near Corozal.

I. COLON SECTION.—From the Caribbean Sea to the mouth of the Mindi River a channel is to be excavated having a bottom width of 500 ft. and a depth of 42 ft. below mean tide. It is not intended at the present time to construct either the breakwater or jetty [in Luron Bay] and they may be omitted in whole or in part, or other works for the protection of the channel may be built. The channel may also be widened to 1,000 ft. or more from the deep water in the Caribbean Sea to the mouth of the Mindi River.

The material to be excavated on this portion is mostly soft mud and this can be excavated by dredging. Some of it may be coral rock. A part or all of this material may be deposited in the Gatun dam, hereafter referred to, if directed by the Chief Engineer. The estimated quantity of material to be excavated for the channel 500 ft. wide is 8,455,000 cu. yds. The entrance to the old partially constructed canal is now used for construction purposes and will continue to be so used for this purpose. It may be widened and deepened to such extent as may be deemed necessary by the Chief Engineer. The amount of material to be excavated for this purpose may reach about 1,000,000 cu. yds.

II. MINDI SECTION.—From the mouth of the Mindi River to the Gatun locks the canal is to have a bottom width of 500 ft. and a depth of 42 ft. below mean tide. Some of this excavation can be made by dredging and some of it will be excavation in the dry. The total amount is about 11,000,000 cu. yds. It is believed that nearly one-third of it is indurated clay or rock and two-thirds ordinary earth.

III. GATUN LOCKS.—The Gatun locks are to be built in duplicate—that is, there are to be two sets of locks, side by side. The lift will be overcome by a flight of three locks of 28½ ft. ordinary lift each, or a flight of two locks of 42½ ft. lift each. Neither the details of their construction nor their exact location has yet been definitely fixed. At the upper end of the upper lock and the lower end of the lower lock guide walls will be constructed for the handling of vessels entering or departing. The estimate of quantities in the locks is based on a flight of three having a length of 900 ft. and width of 95 ft. The size of the locks may be increased to 1,000 ft. by 100 ft.

Excavation	3,660,000 cu. yds.
Back fill	660,000 cu. yds.
Concrete	1,302,780 cu. yds.
Cut stone	5,700 cu. yds.
Brick	20,000 cu. yds.
Timber	130,000 ft. B.M.
Cast iron	1,830,000 lbs.
Steel gates	29,230,000 lbs.

No estimate of quantities for a flight of two has yet been made.

IV. GATUN DAM.—This dam reaches from near the Gatun Hills, in which the locks are located, to the hill about 3,500 ft. westward, in which the spillway will be located, and extends from thence in a broken line to the high ground westward. In the construction of this dam all trees, stumps, and roots from the site are to be removed and the surface excavated to such depth that the impervious material of which the dam will be composed will come into direct contact with that on which it is to rest. Other work to be done may be the cutting off of the flow of water through any pervious material that underlies the dam.

The object of this dam is to form a reservoir in which the floods of the Chagres will be received. Its area will be about 110 square miles. The dam will be constructed partly from excavations made for the canal, delivered by pumps or otherwise, wherever such material is deemed suitable. Other material will be procured where directed by the Chief Engineer. The dam is to have a height of about 135 ft. above sea level. The width on top is to be 100 ft. The slopes above lake level are 3 on 2, and below this 1 on 3 on the lake side and 1 on 2 on the opposite side. Its length will be about 7,700 ft. and the width at bottom about 2,625 ft. The total amount of material in the dam is estimated at 21,200,000 cu. yds.

V. REGULATING WORKS.—Works for regulating the level of the lake will be located in the hill which lies about midway between the two extremities of the dam. These consist of a system of Stoney gates constructed on foundations of concrete. The gates proposed are almost exact counterparts of those built for controlling the flow of water in the lower end of the Chicago Drainage Canal. It is possible, however, that the size or location of these regulating works may be changed. The following is an approximate estimate of quantities entering in their construction, if located as now proposed.

Excavation	1,580,000 cu. yds.
Concrete	189,000 cu. yds.
Metal in sluices	5,000,000 lbs.

VI. LAKE SECTION.—From the Gatun locks to San Pablo, a distance of about 15½ miles, only a small amount of excavation will be required. The width of the channel for this distance will be at least 1,000 ft., and all growth within 50 ft. of water surface of lake for that width must be destroyed or removed. The depth is to be 45 ft. Farther up the lake, as the amount of excavation necessary to obtain this depth increases, the width of the channel will be decreased, first, to 800 ft. for a distance of 3.86 miles, from near San Pablo to Juan Grande; then to 500 ft. from Juan Grande to Obispo, a distance of 3.73 miles; then to 300 ft. from Obispo to Las Cascadas, a distance of 1.55 miles, where will begin the Culebra cut. The total estimated amount of material to be excavated in this section is about 24,000,000 cu. yds.

The channel between Matachin and Bas Obispo may be narrowed 100 ft., in which case there will be a corresponding reduction in quantity of material to be excavated. About one-half of this may be rock.

VII. CULEBRA SECTION.—From Las Cascadas to near Paraiso, a distance of 4.7 miles, the width will be 200 ft. This is the heaviest portion of the work and is known as "the Culebra cut." As the rock is of variable character, it may be necessary to build a protecting wall along a portion of it. It is not practicable, however, at the present time to make any estimate of the amount of concrete that may be needed for this purpose. The material to be excavated consists of rock of varying degrees of hardness, clay, earth, hardpan, and volcanic material, and the amount to be removed is estimated at about 39,000,000 cu. yds. This estimate is based on slopes of 3 on 2 above and 10 on 1 below the berm. It may prove that the character of the material is such that the slopes may be flattened or steepened and the quantities, therefore, increased or diminished.

VIII. PEDRO MIGUEL SECTION.—From near Paraiso, the end of the Culebra cut, to the Pedro Miguel lock, a distance of 1.88 miles, the canal will have a width of 300 ft. The amount of material to be excavated in that section is 6,835,000 cu. yds. Some of it is rock and some is soft earth.

IX. PEDRO MIGUEL LOCK.—The Pedro Miguel lock will have a lift of 30 ft. It will be in duplicate and will have approach walls constructed at each end. The details of the lock have not yet been determined. A short dam from the lock to the hill to the northward will be constructed to retain the water in the summit level. An approximate estimate of the quantities entering in the construction is as follows:

Excavation	1,170,000 cu. yds.
Small dam	1,100,000 cu. yds.
Back fill	390,000 cu. yds.
Concrete	513,612 cu. yds.
Cut stone	4,000 cu. yds.
Brick	8,000 cu. yds.
Timber	85,000 ft. B.M.
Cast iron	732,000 lbs.
Steel gates	19,500,000 lbs.

X. LAKE SOSA SECTION.—From Pedro Miguel lock the channel will have a width of 500 ft. for a distance of 1.87 miles. It will then increase to 1,000 ft. or more for a distance of 3.61 miles to near Sosa Hill on the shore of Panama Bay, where the Sosa locks will be located. Some of the excavation in this section is rock, and other portions are soft earth, easily handled with dredges. The total amount is about 1,680,000 cu. yds.

XI. SOSA LOCKS.—The Sosa locks are to be in a flight of two with lift of 27½ ft. each, and to be in duplicate. The details of these locks have not yet been determined.

but the following is an approximate estimate of the quantities of material that will enter in their construction:

Excavation	1,430,000 cu. yds.
Back fill	950,000 cu. yds.
Concrete	992,800 cu. yds.
Cut stone	6,000 cu. yds.
Brick	14,000 cu. yds.
Timber	145,000 ft. B.M.
Cast iron	1,281,000 lbs.
Steel gates	37,180,000 lbs.

XII. LA BOCA SECTION.—A dam will be constructed across the Rio Grande from San Juan Hill to Sosa Hill, another from Sosa Hill to Corozal Hill, and a small dam from Corozal Hill to the high ground to the eastward. These dams will form a lake known as Sosa Lake. It has an area of about 8 square miles and will be provided with regulating works for discharging its surplus waters. The amount of material in these dams is as follows: La Boca dam, 6,300,000 cu. yds.; Corozal-Sosa dam, 5,397,000 cu. yds. Each one of these dams may be constructed in whole or in part from material excavated from the canal. No estimate has yet been made for regulating works.

XIII. PANAMA BAY SECTION.—From Sosa locks to the deep water in Panama Bay, a distance of about 4 miles, the channel is to have a bottom width of 500 ft. and a depth of 50 ft. below mean tide. The mean rise and fall of the tide is about 15 ft., but it may reach as much as 22 or 23 ft. The material to be excavated in forming this channel is believed to be nearly all soft. The estimated amount is 8,528,000 cu. yds.

XIV. PANAMA RAILROAD.—The Panama Railroad will be relocated throughout almost the entire distance from the mouth of the Mindi River to Panama. Some heavy embankments will be required to cross certain portions of Gatun Lake. These embankments it is expected to build of material excavated from railroad cuts or from the prism of the canal.

RAILWAY TRAIN ACCIDENTS in the three months ending June 30, 1906, caused the death of 194 passengers and employees, and damage to rolling stock and roadway amounting to $2,374,000. There were during the quarter 1,588 collisions and 1,515 derailments which caused death or injury to persons, of which 173 collisions and 153 derailments affected passenger trains. For the whole year ending June 30, 1906, there was an increase over 1905 of 546 in the total number of employees killed and 10.098 in the number injured, while there was a decrease of 119 in the number of passengers killed and an increase of 1,145 in the number injured. In coupling accidents, which occur wholly to employees, there was an increase of 68 in the total number killed and of 393 in the number injured, as compared with those reported during the preceding year.

FATAL ACCIDENTS to the number of 1,103 occurred in and about the mines and quarries of the United Kingdom and the Isle of Man during the year 1905, causing the death of 1,304 persons, according to the General Report and Statistics for 1905, of the Home Office (Department of Interior), published in the "Iron and Coal Trades Review." Falls of ground were the cause of 44.6% of the deaths; explosions of fire damp or coal dust, 14.8%; shaft accidents, 6.2%; miscellaneous accidents, 23.7%, and the remainder to surface accidents. Compared with the year 1904 there was a decrease of 55 in the number of fatal accidents and an increase of 102 in the number of deaths due to such accidents. The total number of persons employed at the mines and quarries during the year 1905 was 982,343, which is an increase, over 1904, of 10,467 persons.

THE PHILADELPHIA GARBAGE REDUCTION works were burned early in the morning of Nov. 1. They were owned by the Penn Reduction Co. (E. M. Cooper, Secretary and Treasurer), which has the contract for garbage disposal in Philadelphia. The loss, which is said to involve practically the whole plant, is placed at from $300,000 to $450,000. It is stated that the fire, when discovered, was in the press room. It is possible that the old plant of the American Product Co., at which the garbage was treated for many years, will be used until the burned plant can be replaced by a new one.

THE ENGINEERING FEATURES OF A MODERN department store are well illustrated by the equipment of the new Altman building, recently opened in New York City. The building is 200 by 300 ft. and eight stories high, with a basement extending over the whole area and a sub-cellar extending over about half the area. There are 13 main passenger elevators, 2 special elevators, 4 freight and service elevators, and 1 sidewalk elevator, all of the hydraulic plunger type; and also three electric dumb waiters. For lighting, 1,450 arc lamps and 8,136 incandescent lamps are used. The electric motors are divided as follows: 250 HP. for fans; 200 HP. for cash blowers; 150 HP. for pumps, esculators, elevators, conveyors, etc. Electricity is used to set and wind the clocks throughout the store, to light the emergency gas burners, to heat the pressing and smoothing irons and the glue pots, to operate the sewing machines, and to send in fire alarms to the city and local fire departments. Arc lamps are used in lighting the large spaces of the store in preference to Nernst or incandescent lamps on account of their lower cost of maintenance and more perfect color values. For the window and showcase lighting, however, incandescent lamps are used. A feature of the wiring is that no sweated joints are used, Dossert connectors alone being employed. A wrench and a screw-driver, therefore, are the only tools required in rewiring. The power plant comprises eight Stirling water-tube boilers having a capacity of 2,100 HP.; five direct-connected Ball-Wood four-valve engines driving 115-volt General Electric generators. Three of the generators have each a capacity of 500 KW. for 2 hrs., or 400 KW. continuously, and two have each a capacity of 250 KW. for 2 hrs., or 200 KW. continuously. The total cost per KW.-hr., including all items, is stated to be less than 1½ cts.

PERSONALS.

Mr. J. G. Tabler has been appointed Resident Engineer of the Mexican Central Ry. at Aguascalientes, Mex.

Mr. J. E. Stumpf has been appointed Superintendent of the Wabash R. R. west of the Mississippi, to succeed Mr. Richard Doyle, resigned.

Mr. Henry R. Asserson, Chief Engineer in the Sewer Department, Brooklyn, N. Y., has resigned after 20 years in the city's service.

Mr. W. A. Garrett, formerly General Manager of the Queen & Crescent Route, has become First Vice-President of the Seaboard Air Line Ry.

Mr. A. H. Weber, President of the Board of Water Commissioners of Waterville, N. Y., has resigned, as has also Mr. H. M. King, another member of the Commission.

Mr. E. L. Russel, Vice-President and General Counsel of the Mobile & Ohio R. R., has been appointed Vice-President of the Southern Ry., with headquarters in Mobile.

Mr. Carl P. Abbott, Assistant Engineer of the Queens County Water Co., has resigned to accept a position as Assistant Engineer of the Board of Water Supply of New York City, at White Plains, N. Y.

Mr. W. D. Faucette, Assistant Engineer in charge of the Savannah office of the Seaboard Air-Line Ry., has been made Assistant Engineer in the Chief Engineer's office at Portsmouth, Va. He is succeeded at Savannah by Mr. E. C. Bagwell.

Mr. A. K. Anderson, formerly with the Turner Construction Co., 11 Broadway, New York City, has accepted a position with the South American Construction Co., and has gone to La Paz, Bolivia, as Assistant Superintendent of Railroad Construction.

Mr. James H. Fuertes, M. Am. Soc. C. E., a Hydraulic and Sanitary Engineer, with offices at 140 Nassau St., New York City, has been appointed a member of the Metropolitan Sewerage Commission by Mayor McClellan. He succeeds Mr. Matthew C. Fleming, resigned.

Mr. Willard D. Lockwood, M. Am. Soc. C. E., has resigned as Resident Engineer of the Cobbs Hill Reservoir, Rochester, N. Y., to accept a position with the Scofield Co., Consulting and Contracting Engineers, Philadelphia, Pa. His present address is 6456 Penn Ave., Pittsburg, Pa.

Mr. Edwin B. Katte has been appointed Chief Engineer of Electric Traction of the New York Central & Hudson River R. R. Mr. George A. Harwood has been appointed Chief Engineer of Electric Zone Improvements, exclusive of electric traction and signals. Mr. John D. Keiley has been made Electrical Engineer. Mr. Carl Schwartz has been appointed Engineer of Power Stations. Mr. J. L. Holst has been appointed Engineer of Structures and will have charge of the design and erection of all steel in the Electric Zone, excepting in the Grand Central terminal. He will also be in charge of the design of all buildings not in charge of associated architects, and the design of all masonry and miscellaneous structures north of the south bank of the Harlem River. Mr. W. F. Jordan has been appointed Terminal Engineer and will have charge of the design and construction of the Grand Central Terminal and other work in connection with the electric zone improvements south of the south bank of the Harlem River, except the structural steel design of the Grand Central Station and other work in charge of the associated architects.

Obituary.

R. B. Bradley, a bridge contractor of Bristol, Tenn., was killed by a falling trestle, near Elizabethton, Tenn., Oct. 24. He was 50 years of age.

Col. Le Grand B. Cannon, at one time Vice-President of the Delaware & Hudson Canal Co., died at his summer home at Burlington, Vt., Nov. 3, aged 91 years. He served through the Civil War, being made Colonel Feb. 1, 1862.

Fred. M. Palmer, Assistant Engineer of the Essex Land & Water Power Co., of Lawrence, Mass., died there Oct. 25, aged 52 years. He was a graduate of the Massachusetts Institute of Technology, class of 1875, and had long been connected with the Essex Company.

James D. Yeomans, formerly a member of the Interstate Commerce Commission, died at Washington, D. C., Oct. 31, aged 61 years. Mr. Yeomans was at one time General Superintendent of the Buffalo, New York & Philadelphia Ry., later becoming General Superintendent of the Olean, Bradford & Warren Ry. He was a native of Wyoming County, N. Y.

Peter C. Asserson, Civil Engineer, U. S. Navy, Retired, with rank of Rear Admiral, and Henry R. Asserson, Ex-Chief Engineer of Sewers, Borough of Brooklyn, have formed a partnership as Consulting Engineers, with an office at 59 Pearl St., New York. Admiral Asserson was for 26 years the ranking Engineer of the Naval Corps of Civil Engineers, and during his 32 years of service for the U. S. Government designed and constructed timber and concrete dry-docks, quay walls, railroads, machine shops, foundries, reinforced concrete structures, sewers, shears, cranes, pavements, salt-water fire plants, central electrical power plants, pumping machinery, bridges, etc., distributed from the Puget Sound to Maine and to Florida. The Norfolk and the New York Navy Yards were practically reconstructed by him.

Mr. Henry R. Asserson served the old city of Brooklyn and the present Borough of Brooklyn for 20 years in the water, highways and sewer departments, having constructed the Classical, Willink and Ocean Parkway entrances of Prospect Park, and the Memorial Arch; a large part of the sewerage system of Brooklyn, including several purification and pumping plants; four extensive tunnel sewers of 15 ft. diameter, and various reinforced concrete sewers. His latest design of special note was the Gowanus Canal flushing plant, embracing a tunnel 12 ft. in diameter, which is now in course of construction.

ENGINEERING SOCIETIES.

COMING MEETINGS.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Nov. 13-15. Annual Meeting at Chicago, Ill. Secy., C. E. Jones, Beardstown, Ill.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 3-4. Annual Meeting at New York City. Secy., W. Everett Parsons, 12 Bridge St., New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 4-7. Annual Meeting at New York City. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 2, '07. Annual Meeting at New York City. Secy., L. O. Howard, Cosmos Club, Washington, D. C.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 3. Annual Meeting at Pittsburg, Pa. Secy., F. V. McMullin, 410 Pennsylvania Ave., Pittsburg, Pa.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 8-11. Annual Meeting at Chicago, Ill. Secy., Chas. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 16-17. Annual Meeting at New York City. Secy., C. W. Hunt, 220 West 57th St., New York.

ASSOCIATION OF AMERICAN CEMENT MANUFACTURERS.—The fourth annual meeting of the association will be held at Hotel Astor, New York City, Dec. 11-12. Business sessions will be held Tuesday, Dec. 11, followed with a banquet in the evening in the Banquet Hall of the hotel. Wednesday will be devoted to discussions, etc. Asst. Secy., Mr. C. Earle E. Bottomley, 1232 Land Title Building, Philadelphia, Pa.

NATIONAL ASSOCIATION OF CEMENT USERS.—The annual meeting of the association will be held at Chicago, Ill., Jan. 8-11. Business sessions will be held morning and evening, while the afternoons will be spent in visiting the exhibits, which will be located at Tattersall's. It is the intention of the committee in charge of this feature of the convention to devote each afternoon to a special class of exhibits.

NEW JERSEY SANITARY ASSOCIATION.—The thirty-second annual meeting of the association will be held at "The Laurel-in-the-Pines," Lakewood, N. J., Nov. 16-17. Ten papers will be read at the convention, some of the more interesting being: "The Present Status of Sewage Disposal in the United States and Great Britain, Mr. Henry Hewat; "The Progress of Sewage Disposal in New Jersey," Mr. Boyd McLean; "School Architecture from a Sanitary Standpoint," Mr. Nathan Myers. Reports of committees will include the following: "The Transmission of Disease by Flies, Its Control and Prevention," Dr. Gordon K. Dickinson; "Medical Inspection of Schools," Dr. Joseph Tomlinson. Secy., Dr. James A. Exton, Arlington, N. J.

CONSTRUCTION NEWS

Supplement to ENGINEERING NEWS. New York, November 8, 1

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CONSTRUCTION NEWS.

PLANS AND SPECIFICATIONS ON FILE.

The following Plans (P.), Specifications (S.) and Bidding Sheets (B. S.) may be seen at the office of The Engineering News Publishing Co., 220 Broadway, New York:

Bids close.	Work.	Place.	On file.	See issue
Nov.				
*12	Boilers.	Boston, Mass.	P., S. & B. S.	10-25
*15	Dam, excavation.	N. Yakima, Wash.	P., S. & B. S.	9-27
*15	Canal, dam, tunnels.	N. Yakima, Wash.	P., S. & B. S.	9-27
*15	Steel bars, etc.	Lascruces, N. Mex.	S. & B. S.	10-18
*20	Bridge.	Winnipeg, Man.	P., S. & B. S.	10- 4
Dec.				
11	Suction dredges.	Panama	S. & B. S.	11- 8
*15	Ditches.	Glendive, Mont.	P., S. & B. S.	11- 1

*Work advertised in Engineering News.

NOTE.—We are desirous of securing specifications and bidding sheets (and plans when not too bulky) of pending work for file in our New York office for the benefit of contractors or others who may be interested in the work. If more sets than one are sent us we shall be pleased to distribute these to contractors who ask for them. When the work is advertised in Engineering News a note that the plans are filed with us will be added to the advertisement without cost.

LIST OF CONTRACTS PENDING.

LIGHT, HEAT AND POWER PLANTS.

Bids close.	Work.	Place.	On file.	See issue
Nov. 10.	Light plant,	Lynchburg, Va.		Oct. 25
Nov. 12.	Light plant,	Mobile, Ala.		Oct. 25
Nov. 13.	Electric supplies,	Washington, D. C.		Oct. 25
Nov. 20.	Electrical supplies,	Washington, D. C.		Nov. 8
Nov. 22.	Lighting,	Minneapolis, Minn.		Nov. 8
Nov. 23.	Light plant,	Green Bay, Wis.		Nov 1
Nov. 27.	Power-house,	Norfolk, Va.		Nov. 1
Nov. 29.	Power,	Peterboro, Ont.		Nov. 1
Dec. 17.	Power-house,	Sault Ste. Marie, Mich.		Nov. 8

BRIDGES.

Nov. 8.	Bridges,	Atlanta, Ga.		Oct. 4
Nov. 8.	Bridge,	Independence, Mo.		Oct. 25
Nov. 10.	Bridges,	Wichita, Kan.		Nov. 1
Nov. 12.	Bridge,	Leavenworth, Wash.		Nov. 8
Nov. 14.	Bridge,	Houston, Tex.		Nov. 8
Nov. 14.	Bridge,	Napa, Cal.		Nov. 8
Nov. 14.	Bridges,	Independence, Mo.		Nov. 8
Nov. 14.	Bridge,	Salem, Mass.		Nov. 1
Nov. 14.	Bridge floor,	Columbus, Ohio.		Oct. 25
Nov. 19.	Bridge,	Kansas City, Kan.		Nov. 8
Nov. 19.	Bridges,	Independence, Mo.		Nov. 8
Nov. 20.	Bridge,	Winnipeg, Man.		Oct. 4
	Advertised, Eng. News, Oct. 4 to 25.			
Nov. 21.	Bridge,	Perth Amboy, N. J.		Nov. 1
Nov. 29.	Bridge,	Gilroy, Cal.		Oct. 25
Dec. 3.	Bridge,	De Funiak Springs, Fla.		Nov. 8
Dec. 15.	Bridge,	Carthage, Tenn.		Nov. 8
	Advertised, Eng. News, Nov. 8 and 15.			

BUILDINGS.

Nov. 8.	Library,	Cincinnati, Ohio		Nov. 1
Nov. 8.	Repairs,	New York, N. Y.		Nov. 1
Nov. 8.	Officers' quarters, etc.,	Fort Leavenworth, Kan.		Oct. 25
Nov. 8.	City hall,	Caruthersville, Mo.		Oct. 18
Nov. 8.	Storehouses,	Dover, N. J.		Oct. 18
Nov. 8.	Court-house,	Bloomington, Ind.		Oct. 11
Nov. 8.	Quarantine buildings,	Portland, Me.		Oct. 11
	Advertised, Eng. News, Oct. 11 and 18.			
Nov. 9.	Hardware,	Indianapolis, Ind.		Oct. 11
Nov. 9.	Refrigerator plant,	New York, N. Y.		Nov. 1
Nov. 9.	Repairs,	New York, N. Y.		Nov. 1
Nov. 10.	Theater,	Chicago, Ill.		Oct. 25
Nov. 12.	Heating apparatus,	Superior, Wis.		Oct. 18
Nov. 12.	Steam heating plant,	Hayward, Wis.		Oct. 18
Nov. 12.	Mess-hall,	Washington, D. C.		Nov. 1
Nov. 12.	Electrical equipment,	New York, N. Y.		Nov. 1
Nov. 14.	Buildings,	Des Moines, Iowa		Nov. 1
Nov. 14.	Engine-house,	Hoboken, N. J.		Nov. 1
Nov. 14.	Engine-house,	New York, N. Y.		Nov. 8
Nov. 14.	Heating,	Springfield, Md.		Nov. 8
Nov. 15.	Manufacturing supplies,	New York, N. Y.		Nov. 8
Nov. 15.	Building,	Washington, D. C.		Nov. 1
Nov. 16.	High school,	Paterson, N. J.		Nov. 1
Nov. 19.	Elevator,	Burlington, Vt.		Oct. 25
	Advertised, Eng. News, Oct. 25 and Nov. 1.			
Nov. 21.	Marble work,	Washington, D. C.		Oct. 25
	Advertised, Eng. News, Oct. 25 to Nov. 8.			
Nov. 27.	College building,	Akron, Ohio		Nov. 8
Nov. 28.	Industrial building,	Cleveland, Ohio.		Nov. 8
Nov. 28.	Public building,	Edmonton, Alta.		Nov. 8
Nov. 29.	Buildings,	Fort Ethan Allen, Vt.		Nov. 1
	Advertised, Eng. News, Nov. 1 to 22.			
Dec. 1.	Building,	Raleigh, N. C.		Nov. 1
Dec. 3.	Leprosy station,	Hawaii		Nov. 1
	Advertised, Eng. News, Nov. 1 and 8.			
Dec. 20.	Plans and specifications,	Shreveport, La.		Oct. 4

WATER SUPPLY AND IRRIGATION.

Nov. 8.	Pump,	Yonkers, N. Y.		Oct. 11
	Advertised, Eng. News, Oct. 11.			
Nov. 8.	Wells,	Kewanee, Ill.		Nov. 8
Nov. 9.	Tunnel,	Boston, Mass.		Oct. 18
	Advertised, Eng. News, Oct. 18 and 25.			
Nov. 10.	Cocks,	Washington, D. C.		Nov. 1
Nov. 12.	Cast-iron pipe,	Holyoke, Mass.		Oct. 11
	Advertised, Eng. News, Oct. 18.			
Nov. 12.	Boilers,	Boston, Mass.		Oct. 25
	Advertised, Eng. News, Oct. 25 and Nov. 1.			
Nov. 12.	Pipe,	Holyoke, Mass.		Nov. 8
	Advertised, Eng. News, Nov. 8.			
Nov. 14.	Stop-cocks,	Portland, Ore.		Nov. 8
Nov. 14.	Filtering materials,	Philadelphia, Pa.		Oct. 18
	Advertised, Eng. News, Oct. 18 and 25.			
Nov. 14.	Dam,	Roscoe, Ohio		Nov. 1
Nov. 15.	Tank,	Fortress Monroe, Va.		Nov. 1
	Advertised, Eng. News, Nov. 1 and 8.			
Nov. 15.	Reservoir,	Ft. Wingate, N. Mex.		Oct. 18
Nov. 15.	Water-works,	Suttons Bay, Mich.		Nov. 8
Nov. 19.	Well,	California, Mo.		Nov. 8
Nov. 21.	Pumping engine,	Brockton, Mass.		Oct. 18
	Advertised, Eng. News, Oct. 18 to Nov. 8.			
Nov. 22.	Fountain,	New York, N. Y.		Nov. 8
Dec. 15.	Excavation,	Glendive, Mont.		Nov. 1
	Advertised, Eng. News, Nov. 1 to 29.			
Dec. 15.	Structures,	Glendive, Mont.		Nov. 8
	Advertised, Eng. News, Nov. 8 to Dec. 6.			
No date.	Ditch,	Peru, Ind.		Nov. 8

SEWERAGE.

Nov. 8.	Sewers,	Mobile, Ala.		Oct. 25
Nov. 8.	Pump,	Yonkers, N. Y.		Oct. 11
	Advertised, Eng. News, Oct. 11.			
Nov. 9.	Sewer,	Boston, Mass.		Oct. 25
Nov. 10.	Sewers,	Merchantville, N. J.		Oct. 25
	Advertised, Eng. News, Oct. 25 and Nov. 1.			
Nov. 12.	Sewers,	Cincinnati, Ohio.		Oct. 25
Nov. 12.	Sewers,	Waterloo, Iowa		Nov. 1
Nov. 12.	Sewer,	Youngstown, Ohio.		Nov. 8
Nov. 12.	Sewers,	Selkirk, Man.		Nov. 8
Nov. 13.	Sewers,	New York, N. Y.		Nov. 8
Nov. 13.	Sewers,	Cleveland, Ohio.		Oct. 25
Nov. 15.	Sewers,	Des Moines, Iowa.		8
Nov. 16.	Sewers,	Buffalo, N. Y.		8
Nov. 17.	Sewers,	Fairbury, Neb.		1
Nov. 19.	Sewers,	Washington, Pa.		1
Nov. 19.	Sewer and outfall,	Los Angeles, Cal.		11
	Advertised, Eng. News, Oct. 11 and 18.			
Nov. 19.	Sewer,	Los Angeles, Cal.		18
Nov. 19.	Sewers,	Roanoke, Va.		8
Nov. 26.	Sewers,	Norwood, Ohio		1
Nov. 26.	Sewers,	San Jose, Cal.		8
Nov. 27.	Sewers,	Washington, D. C.		1
	Advertised, Eng. News, Nov. 1 and 8.			
Dec. 1.	Sewers,	Rock Island, Ill.		1

STREETS AND ROADS.

Nov. 8.	Paving,	Mobile, Ala.		25
Nov. 8.	Gravel,	New York, N. Y.		25
Nov. 8.	Gravel roads,	Chehalis, Wash.		18
Nov. 8.	Paving,	Toledo, Ohio		1
Nov. 8.	Road,	Brookville, Pa.		1
Nov. 9.	Paving,	Buffalo, N. Y.		1
Nov. 9.	Paving,	Troy, N. Y.		25
Nov. 10.	Roads,	Port Townsend, Wash.		25
Nov. 10.	Paving,	Scranton, Pa.		8
Nov. 12.	Paving,	Cincinnati, Ohio.		25
Nov. 12.	Road work,	Brazil, Ind.		25
Nov. 12.	Boulevard,	Norfolk, Va.		1
	Advertised, Eng. News, Nov. 1.			
Nov. 12.	Paving,	Port Chester, N. Y.		1
	Advertised, Eng. News, Nov. 1.			
Nov. 13.	Grading,	Ashtabula, Ohio		8
Nov. 13.	Granite entrance,	New York, N. Y.		8
Nov. 13.	Bricks,	Bridgeton, N. J.		8
Nov. 13.	Grading, etc.,	New York, N. Y.		8
Nov. 14.	Paving,	Hoboken, N. J.		1
Nov. 16.	Macadam,	Decatur, Ind.		1
Nov. 16.	Paving,	Buffalo, N. Y.		8
Nov. 20.	Grading,	Cleveland, Ohio		1
Nov. 20.	Paving,	Des Moines, Iowa.		8
Nov. 20.	Macadam,	Addyston, Ohio		8
Nov. 20.	Paving,	Norfolk, Va.		8
Nov. 21.	Roads,	New Brunswick, N. J.		1
Nov. 21.	Asphalt plant,	New York, N. Y.		1
Nov. 28.	Paving,	Montgomery, Ala.		8
Dec. 1.	Crossing,	Williamsport, Pa.		1
	Advertised, Eng. News, Nov. 1 and 8.			

MISCELLANEOUS CONTRACTS.

Nov. 8.	Greenhouses,	New York, N. Y.		Nov. 1
Nov. 8.	Snow removal,	New York, N. Y.		Nov. 1
Nov. 8.	Canal work,	Albany, N. Y.		Oct. 11
	Advertised, Eng. News, Oct. 11 to Nov. 1.			
Nov. 8.	Tunnel,	Boston, Mass.		Oct. 25
Nov. 9.	Canal work,	Albany, N. Y.		Oct. 11
	Advertised, Eng. News, Oct. 11 to Nov. 1.			
Nov. 10.	Light vessel,	Washington, D. C.		Oct. 18
Nov. 10.	Wooden barges,	New Orleans, La.		Oct. 25
Nov. 12.	Athletic field,	New York, N. Y.		Nov. 1
Nov. 12.	Wharf, etc.,	Fort Stevens, Ore.		Nov. 1
Nov. 12.	Cement,	Washington, D. C.		Nov. 1
	Advertised, Eng. News, Nov. 1.			
Nov. 13.	Naval supplies,	Washington, D. C.		Oct. 25
Nov. 13.	Cranes,	Washington, D. C.		Oct. 11
Nov. 14.	Dam,	Roscoe, Ohio		Nov. 1
Nov. 14.	Crematory,	Des Moines, Iowa.		Nov. 1
Nov. 14.	Ordnance,	Washington, D. C.		Nov. 1
Nov. 15.	Entrance,	Brooklyn, N. Y.		Nov. 1
Nov. 15.	Railway grading,	Independence, Kan.		Nov. 1
	Advertised, Eng. News, Nov. 1 and 8.			
Nov. 15.	Canal, dam, tunnels,	N. Yakima, Wash.		Sept. 27
	Advertised, Eng. News, Sept. 27 to Nov. 1.			
Nov. 15.	Dam, excavation,	N. Yakima, Wash.		Sept. 27
	Advertised, Eng. News, Sept. 27 to Nov. 1.			
Nov. 15.	Steel bars, etc.,	Lascruces, N. Mex.		Oct. 18
	Advertised, Eng. News, Oct. 18 to Nov. 8.			
Nov. 16.	Inclined railway,	Niagara Falls, N. Y.		Oct. 25
Nov. 17.	Sea-wall,	Fort Screven, Ga.		Nov. 1
Nov. 23.	Steel horses for dams,	Wheeling, W. Va.		Oct. 25
	Advertised, Eng. News, Oct. 25 to Nov. 15.			
Nov. 24.	Wharves,	New Orleans, La.		Oct. 25
Nov. 24.	Dredging,	Boston, Mass.		Nov. 1
Nov. 27.	Naval supplies,	Washington, D. C.		Nov. 8
Nov. 28.	Dredging,	New York, N. Y.		Nov. 1
	Advertised, Eng. News, Nov. 1 to 22.			
Dec. 1.	Undergrade crossing,	Williamsport, Pa.		Nov. 1
	Advertised, Eng. News, Nov. 1 and 8.			
Dec. 1.	Garbage reduction,	Spain (Foreign)		Oct. 11
	Advertised Eng. News, Oct. 4 and 11.			
Dec. 4.	Naval supplies,	Washington, D. C.		Nov. 8
Dec. 11.	Suction dredges,	Panama		Nov. 8
Dec. 12.	Ship canal,	Panama		Oct. 18
Dec. 20.	Sluice gates,	Wyoming		Nov. 1
	Advertised, Eng. News, Nov. 1 to 29.			
Mar. 18. ('07).	Tunnel,	New Zealand (Foreign).		Sept. 13
	Advertised, Eng. News, Sept. 13 to Mar. 14.			
Apr. 12 ('07).	Ditches,	Brookings, S. Dak.		Oct. 18

CIVIL SERVICE EXAMINATIONS.

Nov. 14.	Electrician,	Wyoming		Oct. 25
Nov. 17.	Chainman,	Albany, N. Y.		Oct. 25
	Advertised, Eng. News, Oct. 25.			
Nov. 17.	Leveler,	Albany, N. Y.		Oct. 25
	Advertised, Eng. News, Oct. 25.			
Nov. 17.	Rodman,	Albany, N. Y.		Oct. 25
	Advertised, Eng. News, Oct. 25.			
Nov. 17.	Inspector,	Albany, N. Y.		Oct. 25
	Advertised, Eng. News, Oct. 25.			
Nov. 17.	Asst. Steam Engr.,	Albany, N. Y.		Nov. 1
Nov. 20.	Arch. Draftsmen,	Washington, D. C.		Oct. 25
Nov. 20.	Jr. Arch. Draftsmen,	Washington, D. C.		Oct. 25
Nov. 20.	Engr. Draftsmen,	Washington, D. C.		Oct. 25
Nov. 20.	Elec. Engrs. & Dftsmen,	Wash., D. C.		Oct. 25
Nov. 20.	Heat. & Ventil. Draftsmen,	Wash., D. C.		Oct. 25
Nov. 21.	Mech. Draftsmen,	Washington, D. C.		Oct. 25
Dec. 4.	Chief, Water Bureau,	Philadelphia, Pa.		Nov. 1
	Advertised, Eng. News, Nov. 1.			
Dec. 5.	Aids,	Washington, D. C.		Nov. 8
Dec. 12.	Topograph. Draftsman,	New York, N. Y.		Nov. 8
	Advertised, Eng. News, Nov. 8 and 15.			

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